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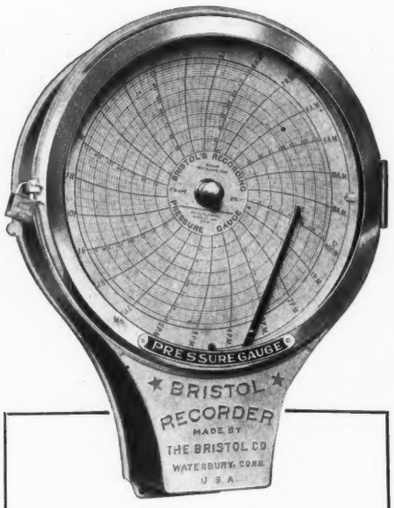

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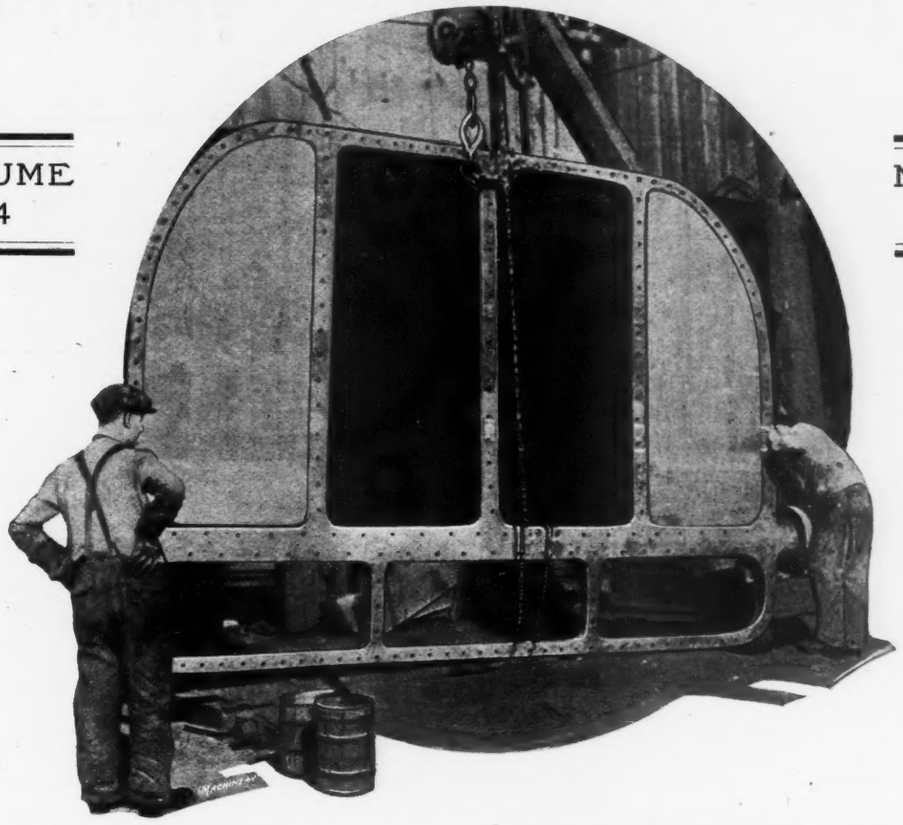

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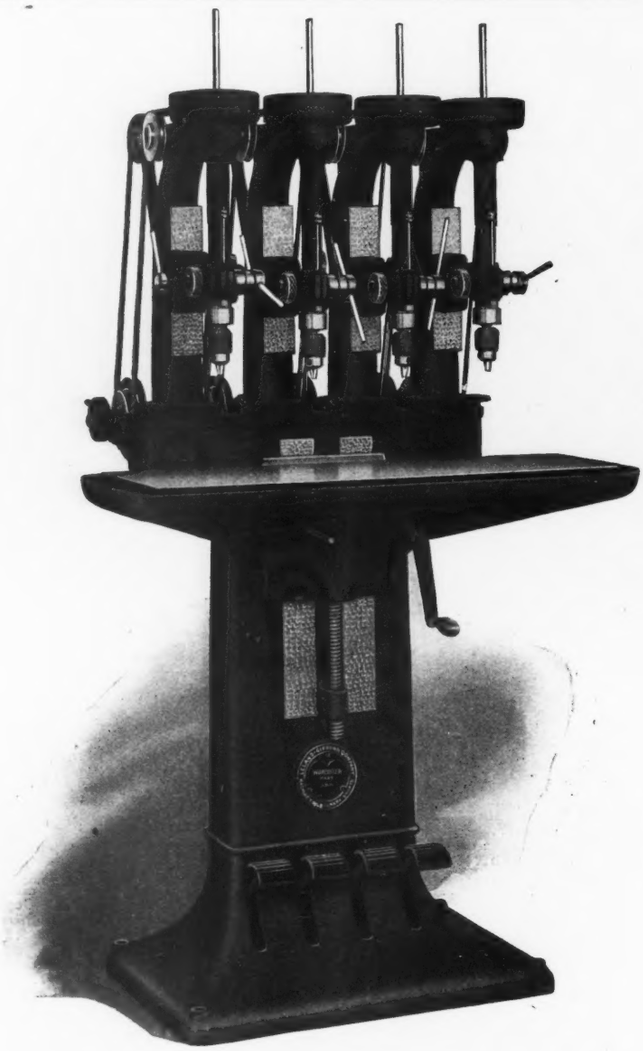

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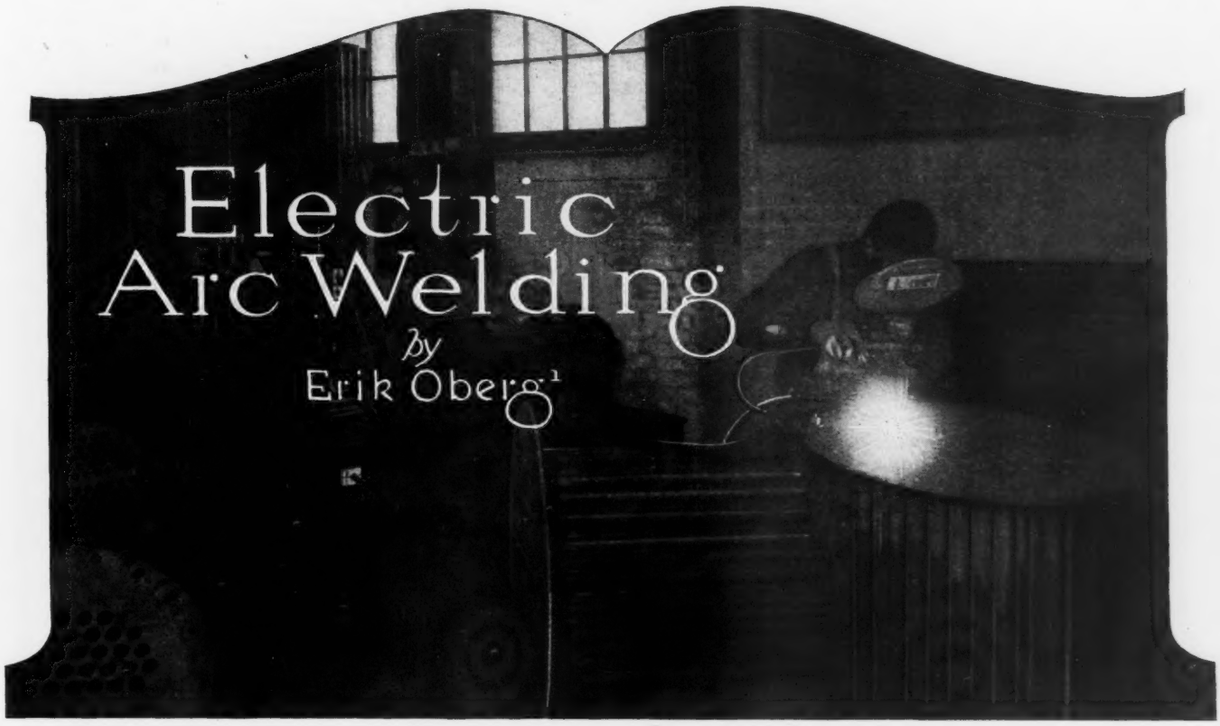


Electric Arc Welding

by Erik Oberg[1]

Electric arc welding is one of several processes of joining metals that have been developed during comparatively recent years. The process has been found to be of great importance on account of its cheapness and the rapidity with which welds can be made, and is now used to a large extent in both repair and manufacturing work. For many classes of work it has taken the place of oxy-acetylene welding because it is cheaper. However, there is a distinct field for both these processes, and it is the purpose of this article to outline the principles of the arc-welding process, and the field for which it is best suited.

THE principle of electric welding is simple; the parts that are to be welded together are heated to a welding temperature by means of an electric current. There are two ways in which the electric current can be utilized for heating to a welding temperature, and according to the methods used, two main processes or systems of electric welding may be distinguished—the electric resistance-welding process and the electric arc-welding process. In the former—the resistance-welding process—the parts to be welded are brought to a welding heat by passing through them an electric current of such voltage and amperage that the resistance to the flow of the current produces sufficient heat so that, when the parts are brought together by a slight pressure, they will be joined by the fusing of the metal—that is, by welding. In the latter system—the arc-welding method—an electric arc is drawn between two electrodes, or between the work and one electrode. This arc is brought into such a position relative to the work that the heat from the arc melts the metal to be welded and enables the parts to be united. There are various modifications of the latter process, but the principle is as described.

The resistance process of electric welding, in turn, may be divided into two specific processes, differing from each other in some important details. The process generally known as the "resistance" or "incandescent" welding process was developed by Elihu Thomson in 1886, and is, therefore, also generally known by the name of the inventor as the Thomson process. The percussion electric welding process, which was developed by L. W. Chubb of the Westinghouse Electric & Mfg. Co., is also in principle a resistance-welding process. The principles and the practice of the resistance-welding process have been covered completely by the articles published in MACHINERY March, 1915; April, 1915; June, 1915; August, 1916; September, 1916; January, 1917; and May, 1917. The present article will deal with the general principles and application of the arc-welding process, describing different methods and equipment.

[1]Associate Editor of MACHINERY

Arc-welding Processes

There are at least four distinct methods of electric arc welding. These are named after the men who are generally credited with their development, and are known, respectively, as the Zerener process, the Bernardos process, the Slavianoff process, and the Strohmenger-Slaughter process. Another method, known as the "voltex" process, may be considered as a development and improvement on the Zerener process. The Slavianoff process is sometimes considered not a distinct method, but merely a development of the Bernardos process.

There is still another method frequently classified as an electric welding process—the La Grange-Hoho method—also known as the "water-pail forge." This differs from the regular resistance or arc-welding processes in that it is simply a method of heating replacing the blacksmith's forge, the welding itself being accomplished by hammering on an anvil, as in ordinary forge welding.

The principle involved in electric arc welding consists chiefly in heating the work to be welded to a welding heat by means of an electric arc produced or struck (1) between the work itself and a carbon electrode, as in the Bernardos process; (2) between the work itself and a metallic electrode, as in the Slavianoff process; or (3) between two carbon electrodes, as in the Zerener process. When carbon electrodes are used, a metal rod is nearly always employed for feeding additional material into the joint to be welded. When a metallic electrode is used, it is made from a metal that is suitable for feeding into the joint to form the material required to complete the weld. It is generally conceded that, where applicable, the arc-welding process is cheaper than the oxy-acetylene or oxy-hydrogen welding processes.

Zerener Arc-welding Process

In the Zerener process, two carbon electrodes, so arranged in a holder as to form a vee, are employed. An arc is drawn between the carbon electrodes, and is caused to impinge upon the metal surfaces to be welded by being so located in relation to a powerful electromagnet that the arc is forced toward the

work. This causes the arc to act in a manner similar to the flame of an oxy-acetylene torch. This welding system, also commonly known as the "electric blow-pipe" method, on account of the peculiarity of the impinging arc, was invented by Dr. Zerener, of Berlin, Germany, some twenty years ago. In this case, no current passes through the work. The Zerener system, as well as all the other arc-welding systems, is based upon the fact that when two rods of carbon or other electrodes connected to the poles of a generator so that current flows through them are brought into contact, a flame will play between them, this flame being known as an "electric arc." The size of the flame or arc may be varied by increasing the gap or distance between the ends of the carbon electrodes, by increasing or decreasing the amount of current passing through the electrodes, or by placing varying resistance in the circuit. The Zerener method is used to a limited extent for comparatively small work on steel and brass and for welding small corners in tubes and tanks. The process, however, is inefficient and complicated, and requires great skill to apply properly. Hence it is not used as extensively as the Bernardos and the Slavianoff arc-welding methods.

In a development of the Zerener arc-welding process known as the "voltex" process, the carbon electrodes contain a small percentage of metallic oxide which is converted into metallic form and then vaporized. The metallic oxide used is frequently oxide of iron. The metallic vapor created by this arrangement increases the size of the arc and minimizes or prevents the carburization of the work by the carbon of the electrodes at the welding point, which is one of the difficulties met with in the regular Zerener arc-welding process.

Bernardos Arc-welding Process

The Bernardos electric arc-welding process, until recently, was the method most extensively used. It is especially adapted to large and heavy work. In this process, the arc is drawn between the metal of the work to be welded and a single carbon or graphite electrode. The process is, therefore, commonly known as the "carbon electrode welding process." It is evident that the metal to be welded forms one electrode and the carbon the other electrode for the circuit. The arc is drawn by touching the electrode to the work and withdrawing it to the proper distance in a manner similar to that in which an arc lamp is lighted. The temperature of the arc is approximately 3500 degrees C. (6300 degrees F.), and the heat is confined to a comparatively small space directly in contact with the arc. The use of a small electrode with low amperage permits comparatively light material to be welded, but the process is generally used with large electrodes and heavy currents for heavy work.

In the early development of this process, it was first attempted to use the carbon electrode as the positive terminal and the work as the negative terminal. These attempts, however, were unsuccessful, because part of the carbon from the electrode was carried into the work, making it very hard and difficult to machine subsequently. It is, therefore, considered advisable always to connect the work to the positive side of the circuit and the carbon electrode to the negative. By this method, also, the greater portion of the heat of the arc is concentrated at the work, which is the positive terminal. The rod of carbon, which forms the negative electrode, varies generally from 3/16 to 1 1/2 inch in diameter, according to the size of the work to be welded. It is held in an insulated holder, which the workman holds in his hand, striking the arc by placing the carbon in contact with the work and quickly withdrawing it a few inches from the metal. The operator then manipulates the arc so as to spread it, and heats the work at or near the point to be welded with what is called a "soaking" heat. The pieces of metal to be welded are melted on their faces together with a small iron rod which acts as a solder and flows in between the two surfaces to be joined. The work is often hammered after the weld has been made. Screens with colored glass windows must be used to protect the eyes of the workmen from the effects of the violet rays of the arc, and gloves are also frequently required, especially when heavy welding is done, for protecting the skin.

The Bernardos system, when properly adapted to the work to be done, is practical, simple and efficient. Direct current is used. The quantity of current, depending upon the thickness to be welded, generally ranges from 200 to 500 amperes.

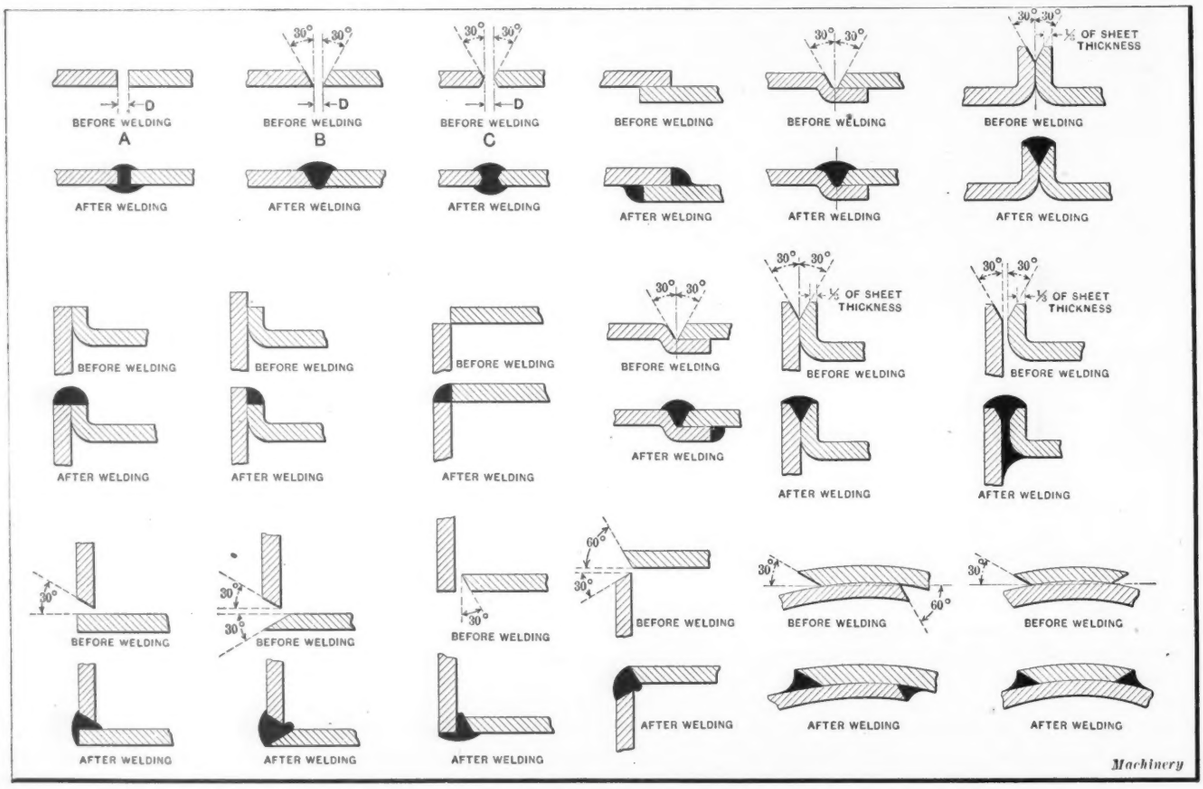


Fig. 1. Methods of preparing Sheet-metal Work for Welding

Slavianoff Arc-welding Process

The Slavianoff electric arc-welding process is also commonly known as the "metallic arc-welding process," because, in this case, a metal electrode is used instead of the carbon electrode.

The objects of using a metal electrode are to prevent the introduction of carbon in the weld, to obtain a stronger weld, and to make vertical and overhead welding possible. The arc is drawn by touching the work with the metal electrode and drawing it away in the same manner as in the Bernardos process. No metal rod to act as a solder is required, however, as the metal electrode itself accomplishes this purpose by gradually melting away and entering the weld. The Slavianoff process produces a softer weld than the Bernardos process, because of the freedom from extraneous carbon in the weld. The arc is smaller than in the Bernardos process and, for that reason, the process is slower, but this is of less importance on smaller work. As the arc itself will carry the metal from the electrode to the work, it is possible to use this method for welding on a vertical wall or overhead, and hence the process is largely used in overhead repair work, in fireboxes, for welding flues in locomotive boilers, and, in general, when repairs must be made in place. It is also largely used for welding steel plate in the manufacture of tanks, etc.

Strohmenger-Slaughter Arc-welding Process

In the Strohmenger-Slaughter electric arc-welding process, the parts to be welded together are placed in the required position, and an electrode, consisting of a soft iron rod covered all over except at the extreme ends with a flux suitable for the metal to be welded, and which also serves as an insulator, is laid along the welding line. The work acts as one electrode, the same as in the Bernardos process. The work and one end of the electrode are brought into contact and an arc is thereby struck. This causes the electrode to melt, the weld being coated with the flux at the same time, thus preventing oxidation. The process is claimed to be successful in the welding of rails and for filling up worn places, but it is not so generally used as the other systems. In this process, either direct or alternating current may be used, but alternating current is preferred. Successful welding has been carried out with 85 volts direct current and 220 volts alternating current.

La Grange-Hoho Electric Heating Process

The La Grange-Hoho electric welding process, strictly speaking, is not an electric welding process at all, but merely an electric method of heating the metal to a welding temperature. The method, sometimes referred to as the "water-pail forge," makes use of a wooden tank filled with a suitable fluid in which the positive electrode of the electric circuit is placed. A negative electrode is connected to the metal to be heated, and this metal is then immersed in the fluid until it reaches a welding temperature. It is then removed and the actual forging or welding is carried out under a hammer or at the anvil in the usual manner.

Earliest Use of Arc Welding

Arc welding appears to have been first used in 1881 by de Meritens for welding together parts of storage-battery plates. In this case, the work was connected to the positive pole of the current supply and a carbon electrode was used. The heat generated by the arc fused the lead of the storage-battery plate, the various parts of which were thus united or welded.

The Electric Arc

An electric arc is formed when a current of electricity passes from one conductor to another through a gas or vapor which has been brought to incandescence by the discharge of electricity. The conductor from which the current passes into the incandescent gas or vapor is known as the "positive" electrode, while the conductor to which the current passes is called the "negative" electrode. It is estimated that approximately 75 per cent of the resistance offered to the passage of a current of electricity from the positive to the negative electrode takes place at the positive electrode. The remaining 25 per cent of the resistance takes place in the medium between the electrodes and in the negative electrode. It is generally believed that the negative electrode offers more resistance to the flow of current than does the gas or vapor between the electrodes in the short arcs that are used in the arc-welding process. As the amount of heat in the arc or electrodes is proportional to the amount of resistance offered to the passage of the electric current, it is evident that the visible arc or flame produces a comparatively small percentage of the total heat of the arc; by far the largest part of the heat is produced on the positive electrode at the point where the arc impinges.

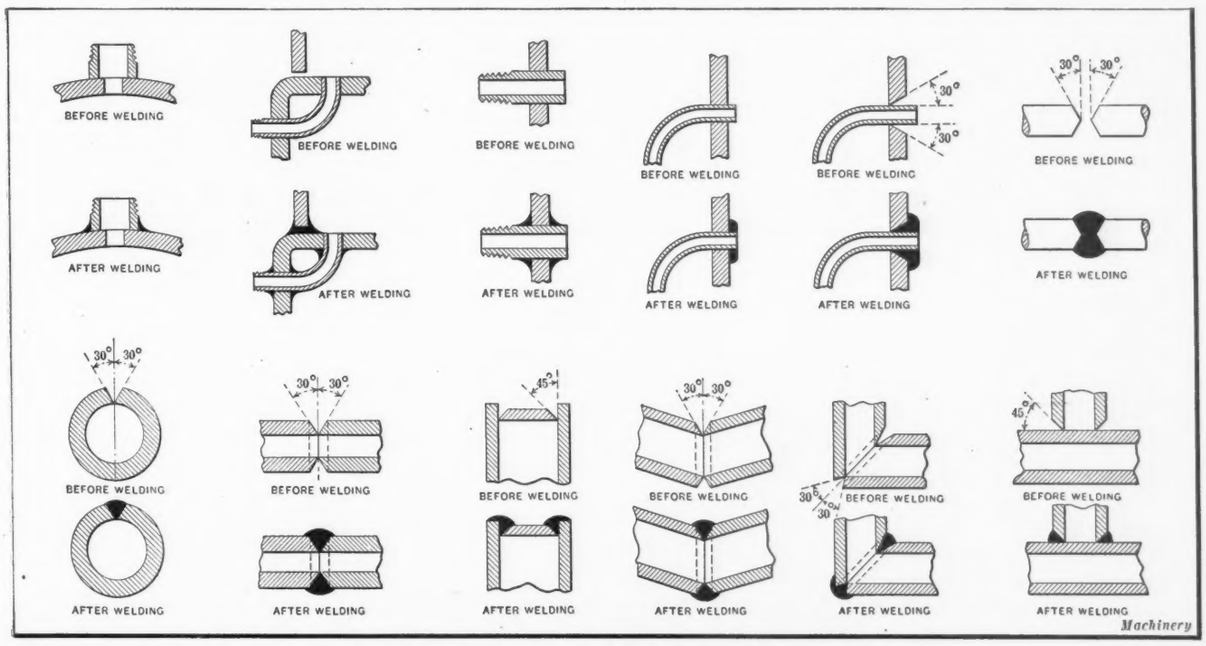


Fig. 2. Methods of preparing Piping and Tubular Work for Welding

The Carbon Arc

The system of electric welding that makes use of the carbon (or graphite) electrode is often known in the shop as "carbon arc welding." The electrode is a rod of carbon or graphite between which and the work the electric arc is drawn until the work is heated to the point of fusion. This method is used for three principal purposes: Its first and most important use is for burning metal off iron or steel parts, which is the simplest application of the electric arc. It is frequently used for reducing scrap material to sizes capable of being easily handled, and for cutting risers and fins from large castings in foundries. Some manufacturers of electric welding apparatus, however, do not recommend it for general use for "cutting"

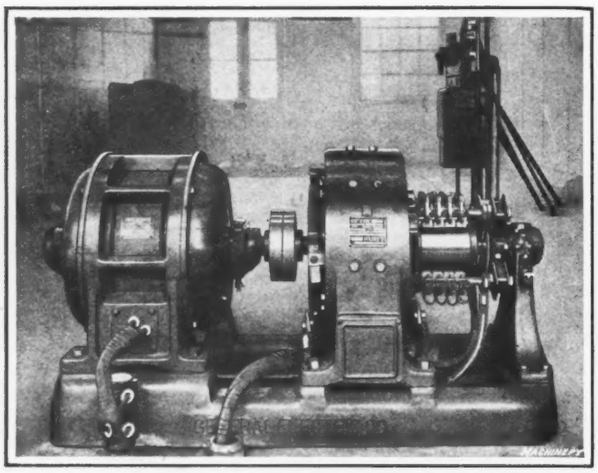


Fig. 3. General Electric 500-ampere Electric Arc-welding Motor-generator Set

structural steel, as cutting of such material, where there are no blow-holes, can be more neatly and cheaply done by oxy-acetylene or oxy-hydrogen torches; but when a small amount of cutting is to be done and an arc-welding outfit is on hand, it provides a convenient means for doing this kind of work, and the method is especially applicable in cutting off pieces to prepare repair work for welding. The second application of the carbon arc is for the welding of very heavy work by the use of heavy currents and large electrodes, and its third application, which is very limited, is in the welding of brass. In each of the two latter cases, a rod of suitable metal must be introduced into the arc, so that the weld can be built up by adding welding material. The metal supplied may be either a rod held in the operator's hand or may consist of small pieces of scrap material which are fused so that they will unite with the part of the work that is already raised to a molten state by the arc, thus forming a solid mass of even structure upon cooling.

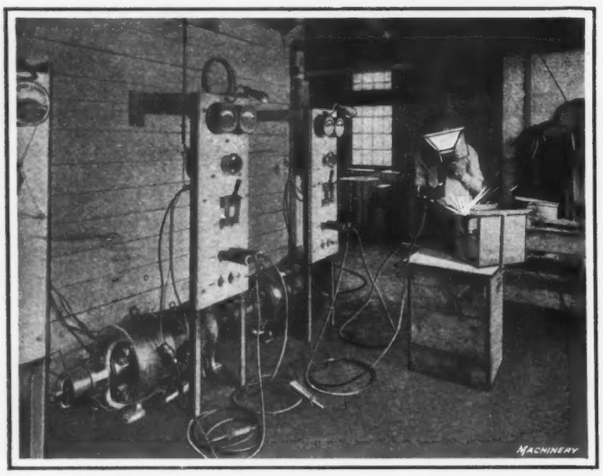


Fig. 4. Lincoln Electric Co. Equipment for Arc Welding

The principal field for the carbon arc for welding is in foundries and steel mills for the repair of imperfect or broken castings of large size. The loss from imperfect castings of large size is always high, but can be reduced to a small percentage by the use of the arc-welding processes, as castings containing blow-holes, cracks, etc., can be readily repaired at small expenditure for material and labor. For all work in which the carbon arc is used, comparatively heavy currents are required, ranging from 200 to 1000 amperes. With these heavy currents, the heat can be applied quickly and can be concentrated at the required point until an intense heat is reached and the process of cutting or welding becomes very rapid. However, the carbon arc is not used anywhere nearly as extensively as the metallic arc, for reasons that will be explained in the following paragraphs.

Polarity for Carbon Arc Welding

As already mentioned, the work is made the positive electrode and the carbon the negative electrode. Two advantages are gained in this manner: (1) Particles of carbon from the electrode are not carried into the weld, and (2) the greater portion of the heat of the arc, being concentrated at the positive terminal, heats the metal to be welded more rapidly.

The Metallic Arc

In the Slavianoff process, commonly known as the "metallic" or "metallic arc" welding process, the metallic electrode—usually made from a soft grade of iron or steel of some special composition, or from bronze for the welding of bronze objects—is brought into a fused state by the heat of the arc, and metal from it is gradually deposited at the point of the weld, where the work is raised to a state of incandescence, so that the metal from the electrode unites intimately with

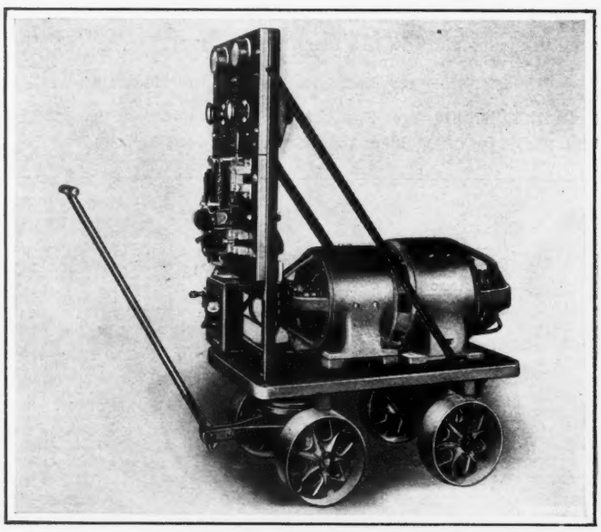


Fig. 5. C & C Electric & Mfg. Co. Portable 150-ampere Constant-current Welding Outfit

it. This method of welding is very rapid, as the softening or melting of the electrode is continuous after the arc is started, and thus the weld is quickly filled with the filling material. The method is extensively used in all classes of repair and reclamation work, as, for instance, in the filling of cracks and blow-holes in castings, in the building up of worn parts of rolls, rails and locomotive wheel tires, in the repairing of cracks in boilers and locomotive fireboxes, in marine repair and construction work, and in many other industries where it is used as a manufacturing method for increasing the speed or convenience with which the finished product may be brought out. Examples of manufacturing work in which the arc-

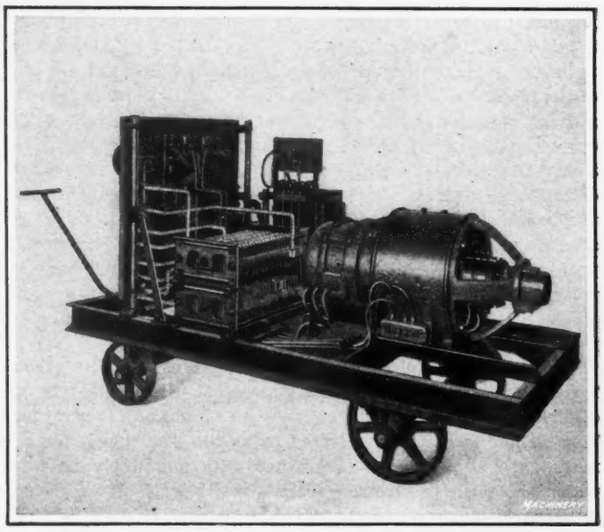


Fig. 6. General Electric Portable 200-ampere Arc-welding Outfit

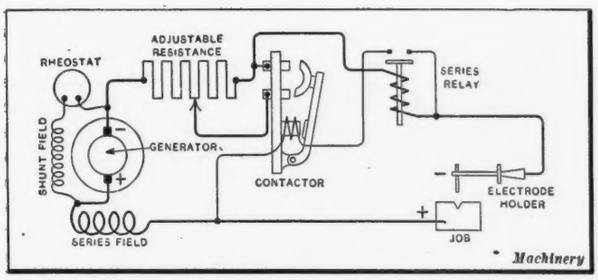


Fig. 7. Diagram of Connections for C & C Electric & Mfg. Co. Arc-welding Equipment

welding process is applied are found in the welding of heads and branches to tanks, in the joining of the seams of tanks and boilers, in the welding of fireboxes, flue sheets, boiler tubes, in the manufacture of steel cars, and in the welding of automobile bodies, rear axle housings, universal joints and other automobile parts, as well as in all classes of pipe and sheet metal work. About 90 per cent of all electric welding is done by the use of metallic electrodes.

The metallic electrode process does not require as heavy a current as the carbon arc. The maximum current required is about 200 amperes. For this reason, it is slower than the carbon electrode process, and the metal is deposited less rapidly. It is deposited more uniformly, however, and a weld made by a metallic electrode is stronger and has a smoother and more regular appearance than a weld made by the carbon electrode; hence metallic electrode welding is employed when the strength of the weld as well as its appearance are of importance.

Polarity for Metallic Arc Welding

On account of the fact that the heat of the positive electrode is greater than that of the negative electrode, the work is made the positive electrode, while the metallic electrode is made the negative terminal. In this way, the piece to be welded, which usually has a much larger mass than the welding electrode or wire, and which consequently loses more heat by conduction, is still enabled to heat rapidly. In a few cases, as in the welding of very thin sheet metal, the welding wire is made the positive electrode in order to reduce the tendency of the arc to burn through the sheet metal. It is only when welding thin sheets by the metallic arc that it is desirable to use the metal electrode as the positive pole. In carbon arc welding, the carbon electrode is always the negative pole, as otherwise the carbon is carried over from the electrode into the weld, causing hard spots, brittleness and unsatisfactory results.

Combination of Metallic and Carbon Arcs

In some cases, especially in repair work, it is necessary to remove some parts of the metal to be welded at the place where the weld is to be made. It may be necessary, for example, to cut out part of a burnt, broken or worn spot in order to insert new material, or to widen a crack in order that the metal from the electrode may be properly deposited in it. As the cutting operation must be performed by means of the carbon arc, the combined use of the carbon and metallic arcs is often desirable, the carbon arc being used for cutting, and the metallic arc for the subsequent welding. Preheating of large castings may also be done in this way, as a large section of the work may be raised to a high temperature by using the carbon arc, after which the actual welding is performed by the metallic arc. The strains in the welded parts are more evenly distributed on account of the preheating, and welds of greater strength are thus obtained.

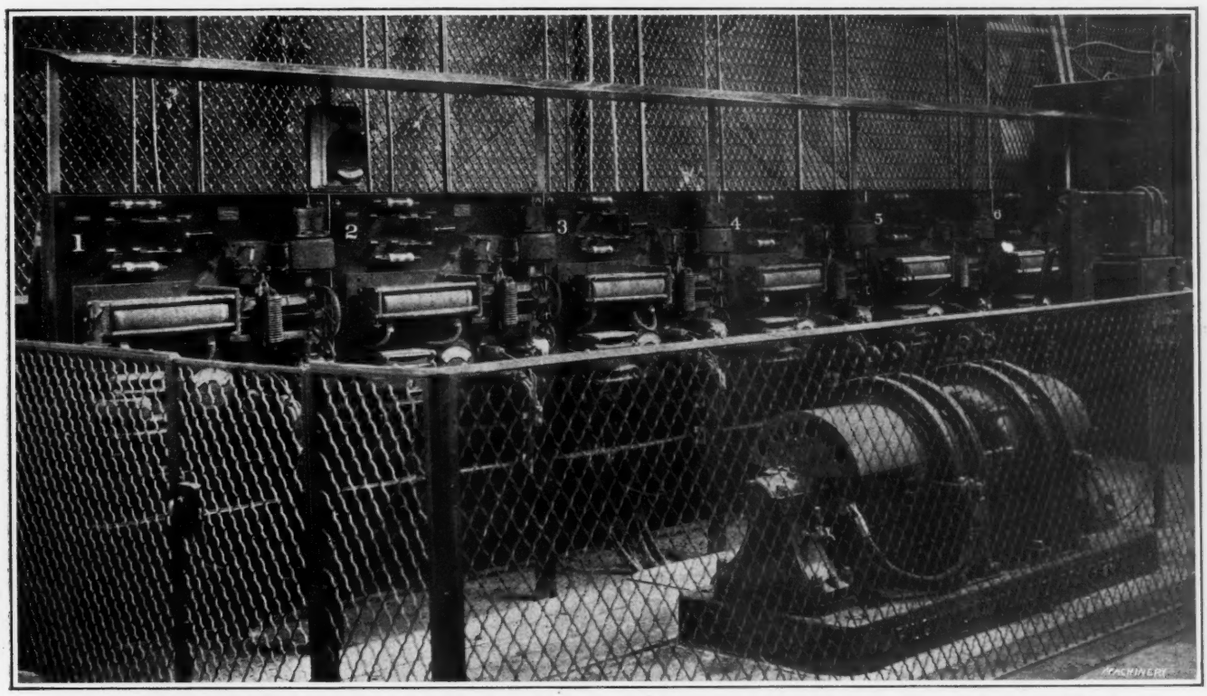


Fig. 8. Wilson Welder & Metals Co. Equipment for Electric Arc Welding—Six-panel Installation at American Locomotive Co., Dunkirk, N. Y.

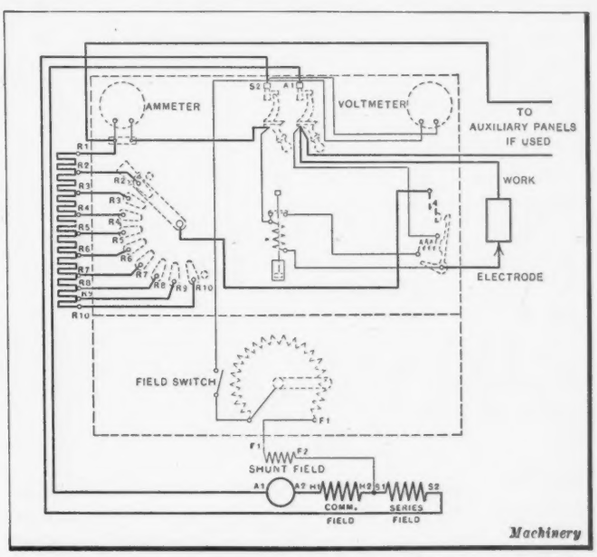


Fig. 9. Diagram of Connections for General Electric Co. Arc-welding Control Panel for controlling Generator and One Welding Circuit

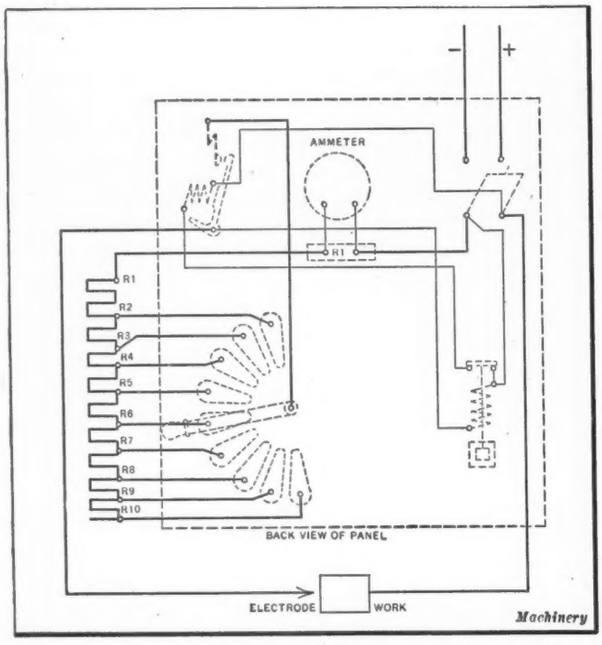


Fig. 10. Connections for General Electric Co. Arc-welding Auxiliary Control Panel for One Welding Circuit

Carbon Electrodes

The carbon electrodes may be made either from a high grade of homogeneous, uncored, hard carbon similar to that used in arc lamps, or from graphite. The former are generally known as "carbon electrodes," while the latter are termed "graphite electrodes." Carbon electrodes are cheaper, but disintegrate more readily. The end of the electrode should be rounded off, but care should be taken not to bring it to a sharp point. In some cases, tapered electrodes are used. The carbon or graphite electrodes used vary in size from ¼ to 1½ inch in diameter. The following have been found, by trial, to be approximately the proper values of current for different sizes of carbon electrodes: ¼ inch in diameter, up to 100 amperes; ½ inch in diameter, from 100 to 300 amperes; ¾ inch in diameter, from 300 to 500 amperes; and 1 inch in diameter, from 500 to 1000 amperes. Graphite electrodes may be used with

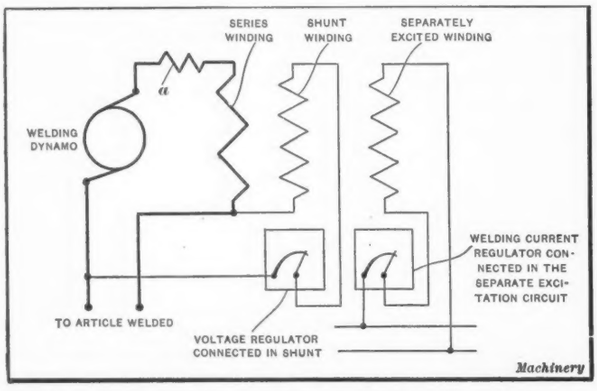


Fig. 11. Wiring Diagram of Kramer Electric Welding Machine

higher current values. They are not extensively used, however, because they are more expensive. The filling material used with carbon electrodes should be of the same kind and quality as the material being welded, except that a somewhat higher percentage of carbon in the welding material is desirable, inasmuch as some of the carbon is burnt out in the welding process.

Metallic Electrodes

The size of the metal electrode used varies with the nature of the work and the current required, but it is ordinarily made from 3/32 to 5/32 inch in diameter. It is necessary in every case to have the proper relation between the current strength and the size of the electrode, because the heat of the arc must be sufficient to raise a spot on the work nearly to the point of fusion, in order that there may be an actual union of the metal from the electrode with the work. Unless the temperature is high enough for this union, the weld will be imperfect and the metal from the electrode will not join properly with that of the work. On the other hand, if the metal is heated to too high a temperature, there is danger of burning it and oxidation also takes place more rapidly, thus impairing the weld. In addition, greater heating and cooling strains are set up in the weld. Therefore the current must be regulated to produce a proper temperature rise in the work, and the size of the electrode must be so selected that there is no danger of overheating or oxidizing the metal when deposited. On the other hand, the electrode must not be too large for the current used, as this would produce an imperfect union, the fusion being slow and imperfect and the welds unsatisfactory.

Metallic electrodes for welding steel or iron are obtainable from supply houses generally, from makers of steel and iron wire, or from the various companies that manufacture electric arc-welding equipment. The electrodes used in connection with practically all welding equipments consist of rods from 1/16 to 1/4 inch in diameter and about 12 inches long; the largest size of electrode is used for cast-iron welding only.

The Wilson Welder & Metals Co., 52 Vanderbilt Ave., New York City, supplies metal electrodes in sizes of from 1/16 to

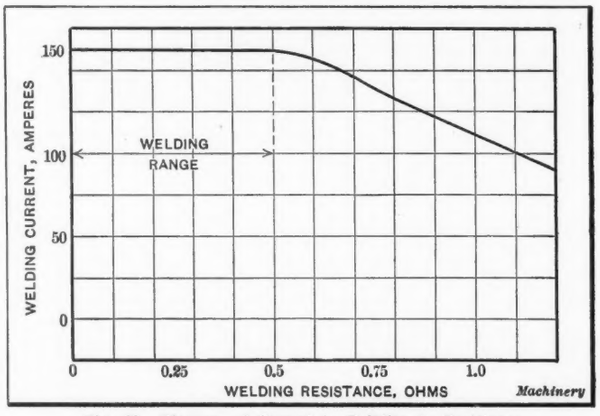


Fig. 12. Diagram of Current in Relation to Resistance

9/32 inch in diameter, the standard size being gage No. 9, which is approximately 5/32 inch in diameter. These electrodes are furnished in five different grades, suitable for boiler repair, steel welding, cast-iron welding, filling castings, and bronze welding, respectively. Experience has shown that in order to secure satisfactory results in electric welding, the use of a proper grade of metal is of as great importance as having a properly designed machine. Recognizing this fact, the Wilson Welder & Metals Co. has developed specially prepared welding metals that are not adversely affected by the heat of the arc. These metals are used in the form of an electrode. This metal is a homogeneous alloy combined with an excess of manganese to compensate for losses while passing through the electric arc, thus insuring a substantial amount of manganese in the welded joint, which is essential to its toughness. In addition, a manganese-copper alloy welding electrode has been developed, which is composed of iron

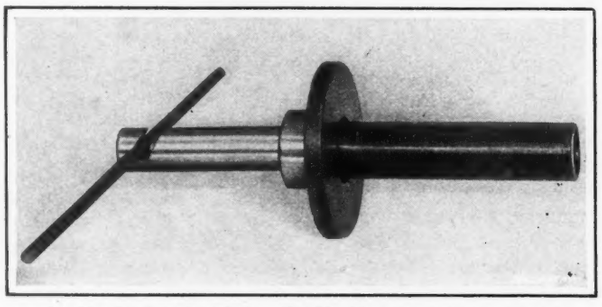


Fig. 13. General Electric Co. Metallic Electrode-holder for Electric Arc Welding

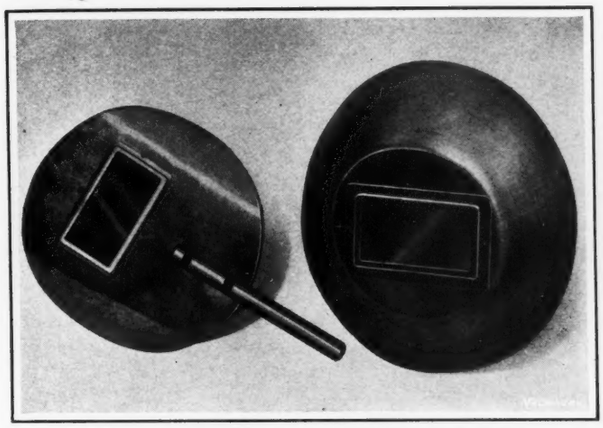


Fig. 14. Front View of Two Types of Welding Shields

homogeneously combined with such an excess of manganese and copper over the amount lost in the arc as will insure to the welded joint an additional degree of toughness and ductility, and at the same time will leave it soft enough to be machined.

The C & C Electric & Mfg. Co., Garwood, N. J., states that, with the company's constant-current low-voltage (16 to 20 volts) system of electric welding, electrodes of Swedish iron (mild steel) are best for all-around welding of steel. They can be used for welding overhead work, as well as vertically (as, for instance, in the welding of flues), without any of the limitations encountered when using electrodes that fuse at an unusually low temperature. One of the great advantages of Swedish iron welding electrodes is that the material always may be depended upon to be uniform.

The Lincoln Electric Co., Cleveland, Ohio, furnishes metallic electrodes 1/8, 5/32 and 3/16 inch in diameter. The smallest electrode is used on sheet metal 1/8 and 3/16 inch thick, and also for welding flues into flue-sheets in locomotive shops. The 5/32-inch electrodes are more generally used than any

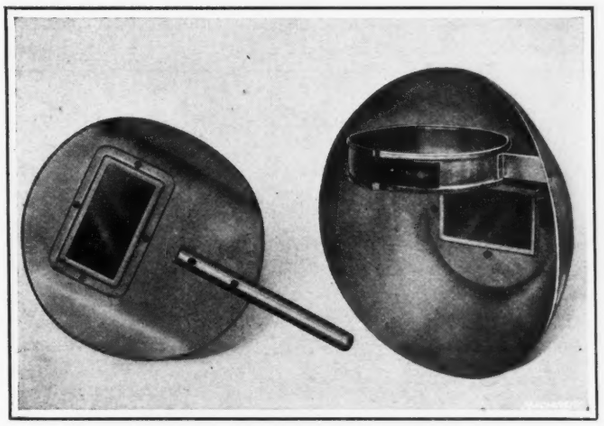


Fig. 15. Rear View of Welding Shields shown in Fig. 14

other size, and are employed for boiler-plate welding in general. The 3/16-inch electrode is used principally for "building up," as, for example, in the building up of worn parts of steel castings. It may also be used for welding when speed is more important than the quality of the work.

Current and Voltage for Carbon Arc

The voltage across the arc varies from 35 to 50 volts, depending partially upon the amount of current being used, but still more upon the length of the arc. The current ranges from 200 amperes up, depending upon the type of work being done. For light work, small electrodes and current values less than 200 amperes can be used. The average type of welding done by the carbon arc requires from 300 to 400 amperes. For cutting, or, more correctly, burning, from 400 to 600 amperes, or more, are required.

Current Required for Metallic Arc Welding

The current required for the metallic arc is smaller than for the carbon arc and seldom exceeds 175 or, at most, 200 amperes for the heavier classes of work; it ranges from this maximum down to 12 or 15 amperes for thin sheet metal work. The generated voltage varies from 16 to 75 volts, according to the make of the equipment used. Metal electrodes also require smaller voltage than carbon electrodes. The voltage at the arc is ordinarily from about 15 to 25 volts. The current and voltage used in electric welding depend to a large extent upon the size of the metal electrode used, as well as upon the composition of the electrode and the nature of the work to be welded. The metallic electrode can be used on much lighter stock than the carbon electrode, but in welding it requires greater ability on the part of the operator on account of the shortness of the arc and the consequent difficulty of maintaining it. The metallic arc is more unstable than the carbon arc, and the operation is more difficult to master, but this is compensated for by the fact that certain classes of welding can be done by the metallic arc process that cannot be done in any other way, as, for example, the welding of overhead or vertical surfaces.

Data on Current and Voltage

According to a report submitted to the convention of the Association of Railway Electrical Engineers and reprinted in the *Railway Review*, December 2, 1916, 1/8-inch mild steel

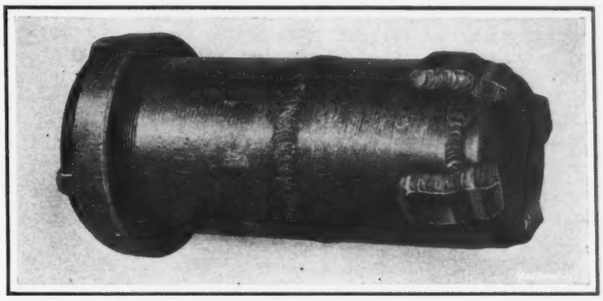


Fig. 16. Six-inch Arc-welded Wrought-iron Pipe tested at Pressure of 1000 Pounds per Square Inch

electrodes used for welding 2-inch flues require a current of from 60 to 90 amperes and a voltage of from 14 to 16 volts; 5-inch flues using a 5/32-inch mild steel electrode require a current of from 110 to 140 amperes with a voltage of from 16 to 20 volts. Mild steel electrodes, 3/16 inch in diameter, require a current of from 150 to 180 amperes with a voltage of from 18 to 25 volts. When carbon electrodes 3/4 inch in diameter are used for cutting, a current of from 250 to 350 amperes and a voltage of from 35 to 50 volts are required. For cutting or burning with carbon electrodes 1 inch in diameter, a current of from 350 to 500 amperes and a voltage of from 35 to 50 volts are required. In some outfits, however, carbon electrodes much smaller in diameter are used, one company employing electrodes only 3/16 inch in diameter.

Sheet Metal Welding

Very thin sheet metal is welded by metallic electrodes with low current values. The General Electric Co., Schenectady,

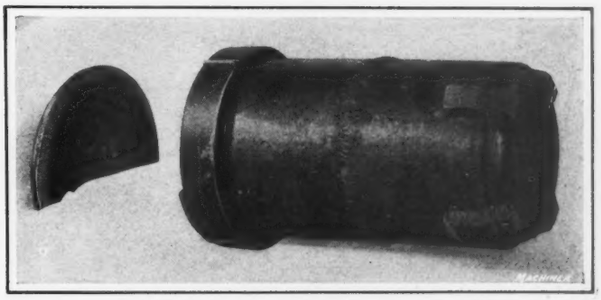


Fig. 17. Eight-inch Arc-welded Wrought-iron Pipe tested at Pressure of 800 Pounds per Square Inch, which was withstood by the Welds but not by the Cap

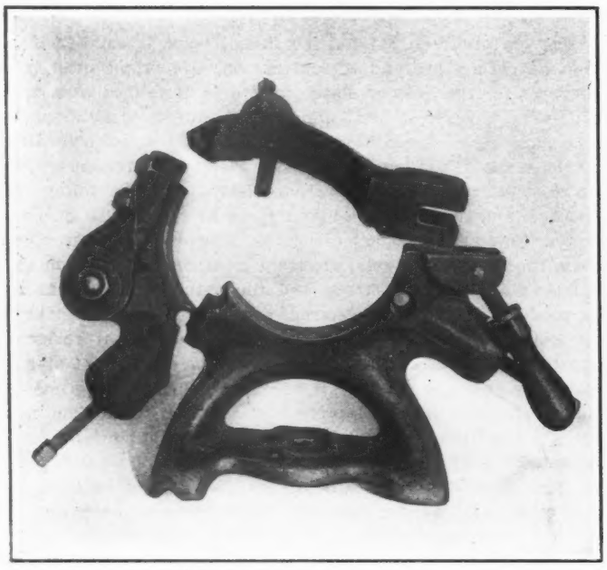


Fig. 18. Broken Lathe Steadyrest

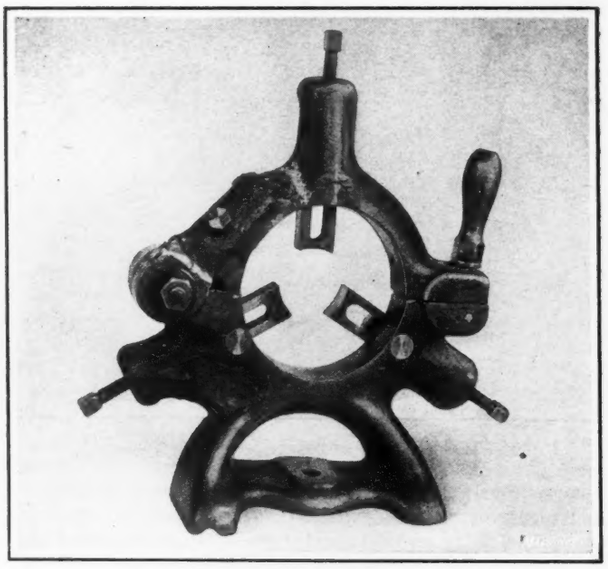


Fig. 19. Lathe Steadyrest shown in Fig. 18 repaired

gives the following data for sheet metal welding based on cost of labor at 30 cents per hour and current at 2 cents per kilowatt hour.

Metal, No. 20 gage or less; metal electrodes, less than 1/16 inch in diameter; current, 10 to 25 amperes; speed, 30 feet per hour; average cost, 1 1/2 cent per foot.

Metal, No. 18 gage to 1/8 inch; metal electrodes, 1/16 inch in diameter; current, 35 to 40 amperes; speed, 30 feet per hour; average cost, 2 cents per foot.

Metal, 1/8 to 3/16 inch; metal electrodes, 3/32 inch in diameter; current, 30 to 50 amperes; speed, 25 feet per hour; average cost, 2 1/2 cents per foot.

Metal, 3/16 to 1/4 inch; metal electrodes, 1/8 inch in diameter; current, 50 to 100 amperes; speed, 20 feet per hour; average cost, 3 to 3 1/2 cents per foot.

Metal, over 1/4 inch; metal electrodes, 5/32 inch in diameter; current, 75 to 150 amperes; speed, 18 feet or less per hour; average cost, 5 cents and up per foot.

The General Electric Co. estimates that the cost of welding 1/4-inch plates by the arc-welding method is about 50 per cent of the cost of welding similar plates by the oxy-acetylene method. To weld steel plates 1/2 inch in thickness with the electric arc will cost less than 40 per cent of the cost with the oxy-acetylene process, and for plates 1 inch in thickness, the cost of arc welding is estimated to be less than 15 per cent of the cost by oxy-acetylene welding.

Advantages of Electric Arc Welding

The following claims of superiority are made for electric arc welding as compared with other methods of welding for materials and conditions for which the method is suitable: First, the high temperature of the electric arc makes it possible to rapidly reduce the metal to be welded to a molten state; the heat being applied rapidly is not carried away from the point of the weld by the heat conductivity of the metal fast enough to lower the temperature at the weld appreciably. Second, the tools for performing the weld are comparatively easy to manipulate and the apparatus required is simpler and easier to handle than that used with gas-welding outfits. Third, for all work, except very thin materials, it is the cheapest welding method available. Fourth, the voltage of the current is so low that the process is perfectly safe, and if the operator is provided with a proper hood or shield to protect him from the light and heat of the arc, he is not exposed to any danger. The heat and light from the carbon arc is much greater than from the metallic arc. Fifth, there is no danger from explosions.

The most important advantage of all, probably, is that welds can be made overhead and on vertical seams by the metallic arc. The arc actually carries the metal particles from the electrode into the weld with considerable force, so that even

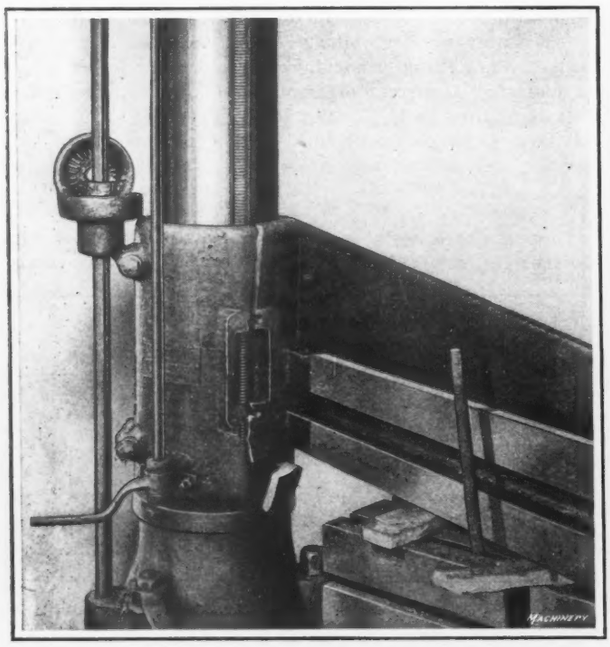


Fig. 20. Broken Arm of Radial Drilling Machine

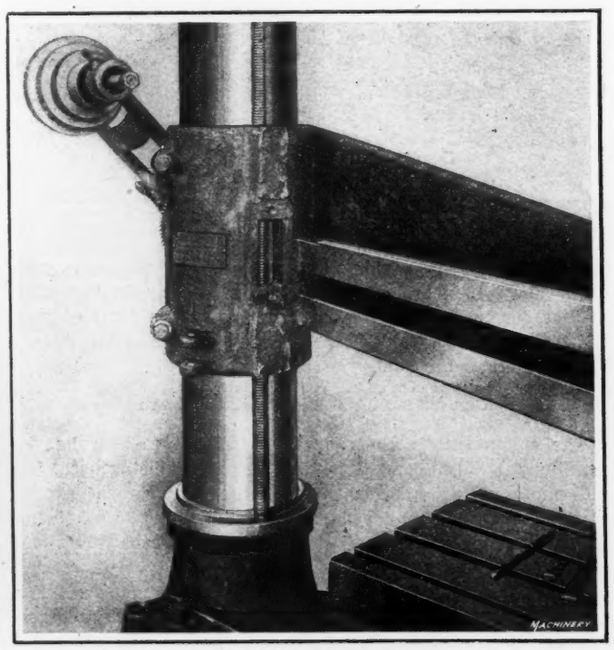


Fig. 21. Arm of Radial Drilling Machine repaired

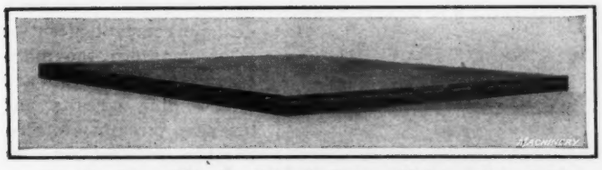


Fig. 22. Steam Plate for Hydraulic Press welded to withstand 150 Pounds per Square Inch Steam Pressure

with an overhead weld, the metal is forced clear through the space between the adjoining surfaces, welding them securely. Overhead welding cannot be done by any other means, and vertical welding only with great difficulty by other methods. The simplicity of electric welding for overhead and vertical seams is, therefore, one of its strongest claims in many instances.

Metals that can be Welded

The metals that are most commonly welded by the electric arc are steel, steel castings, and cast iron. For mild rolled steel and steel castings, electrodes or filling rods of soft iron, preferably Swedish iron, are used; tool steel may also be welded with Swedish iron electrodes. For cast iron, rods of cast iron high in silicon are used. Copper has been welded to steel by using a copper electrode, and brass has also been welded with copper electrodes. In the welding of bronze, a bronze electrode is used. Electric arc welding, however, is most successful in the welding of steel, steel castings, and cast iron; but on account of the great heat of the arc, it cannot be used successfully, except by expert welders, for welding cast-iron sections that are thinner than 1/4 inch. It is not practicable to weld aluminum with the electric arc, the oxy-acetylene process being best for this metal. It is also likely that the oxy-acetylene welding process is preferable for the welding of copper, brass and bronze, although there may be instances when these metals must be welded overhead or along vertical seams, in which case the arc-welding process would have to be used.

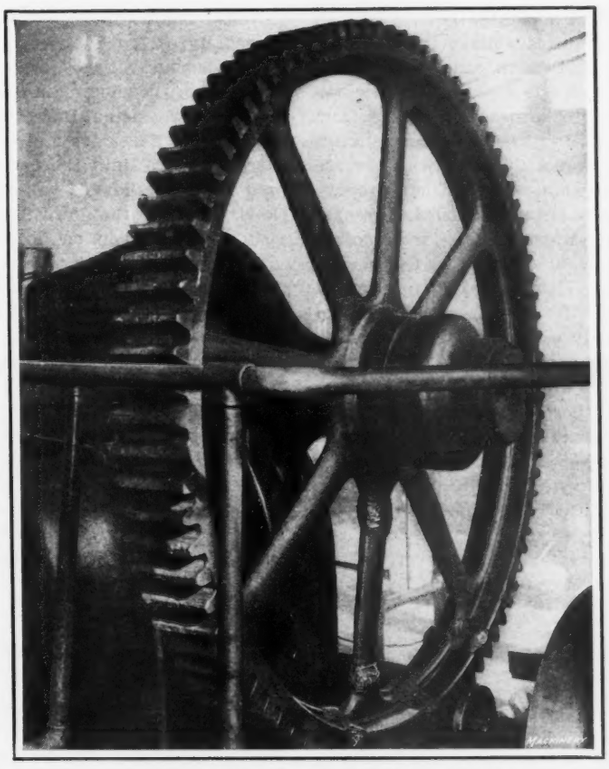


Fig. 23. Cast-iron Gear repaired by Arc Welding

Carbon electrodes are used for filling in large cavities in cast iron, by melting into place a cast-iron rod of, say, 1/2 inch diameter. A cast-iron metallic electrode of a diameter of about 1/4 inch may also be used. Some makers of electric welding equipment recommend the use of soft iron electrodes on cast iron as well as on steel, and one concern uses a specially prepared soft iron electrode containing manganese.

Preparing Work for Welding

The preparation of the work for welding depends upon the kind of work to be done, the thickness of the parts to be welded, and their shape. In Figs. 1 and 2 are shown a number of examples of work to be welded, and in each case the method of preparing the work for welding, and the appearance of the weld after the work is completed, is shown. In Fig. 1 is indicated at *A* the method of preparing sheets less than 1/4 inch in thickness. For sheets up to 1/16 inch in thickness, space *D* should be 1/32 inch. For sheets between 1/16 and 1/8 inch in thickness, it should be about 3/32 inch; and for sheets from 1/8 to 1/4 inch in thickness, space *D* should be about 5/32 inch. At *B* is shown the preparation of sheets from 1/4 to 1/2 inch in thickness, where space *D* should be 3/32 inch. At *C* is shown plate above 1/2 inch in thickness; here space *D* should be 5/32 inch. A study of the various conditions illustrated in Figs. 1 and 2 will give a good idea both of the possibilities of electric welding and the method by which it is accomplished.

Preheating

Cast and malleable iron can be successfully welded by the electric arc process, but it is generally necessary to preheat the castings, either by the use of the carbon electrode or by means of gas, coal or oil fires; the preheating is continued until the work is brought up to a red heat, and the heat is carried well back from the welding surfaces so as to avoid cooling strains and cracks when the metal cools after welding. The work must be kept hot during the time the weld is made, and means must be taken to have it cool down slowly after welding.

Equipment Required for Arc Welding

The simplest possible outfit for arc welding would consist of any source of direct-current supply, an adjustable resistance for regulating the current and bringing the voltage down to that required in the welding circuit, and an electrode holder. The present arc-welding outfits, however, are made somewhat more elaborate in order to obtain greater economy. The current is usually furnished by a low-voltage generator which is driven by a motor or sometimes by other means like a belt or chain drive. Generally, motor-generator sets or dynamotors are used for the power supply. The equipment further includes a switchboard having on it the starting apparatus for the motor end of the outfit, if motor-driven; the control and indicating apparatus for the generator, consisting of a field regulator, voltmeter, and ammeter; and a regulating apparatus for the arc circuit, consisting of a set of current-regulating switches with resistance, and usually some form of automatic switch or contactor. Where several welders use the same stationary outfit, there is, in addition, a control panel for each welding station or circuit. The operator's tools and equipment consist of electrode holders with cables for each welding station, and face shields

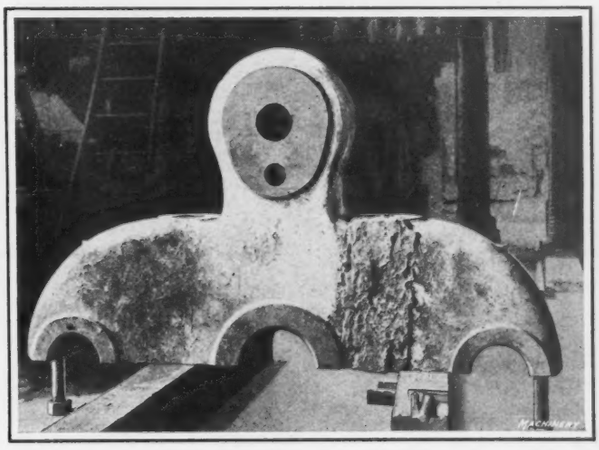


Fig. 24. Bearing Cap for 500-ton Punch Press repaired with Carbon Arc

or hoods for protection against the light and heat.

Motor-generator Sets

As the alternating-current arc varies from a maximum to a minimum at each reversal of the current, it is not suitable for electric arc welding. The direct-current arc, on the other hand, is practically steady; so direct current is used; only a low voltage is required. The metallic arc requires from 15 to 25 volts, while the carbon arc requires from 35 to 50 volts, according to the equipment used. Special welding equipment in the form of generators and control apparatus is used only in order to obtain current at the required voltage economically. As far as the welding is concerned, work can be done with the 250-volt direct current having the necessary resistance ballast; but it would be necessary to reduce the voltage from 250 volts to the low voltages required in the welding circuit. As this is done by inserting resistance in series with the arc to absorb the excess voltage, it is plainly an inefficient process, as the voltage absorbed by the rheostat is wasted. Assume that the supply circuit is 250 volts and that the arc requires 25 volts; then it is obvious that nine-tenths of the energy taken from the mains is wasted in the rheostat; and in the extreme case of a supply circuit of 550 volts and a metallic arc using only 15 volts, the energy used would be so small a fraction of the energy taken from the line that practically all the energy of the supply circuit would be wasted.

In order to avoid these losses, therefore, the various manufacturers of electric welding apparatus have developed special low-voltage generators and methods of control that give the maximum of efficiency combined with flexibility and circuit protection. The generators are usually furnished as part of a motor-generator set, although they can be furnished for belt drive if desired. The motor-generator set, however, is the most desirable equipment for several reasons: It is a self-contained unit; it does not demand constant attention when running; the maintenance cost is low; and the welding circuits and the shop circuits are electrically independent, so that short-circuits in the welding circuit will not seriously interfere with the shop circuits. The voltage on the welding circuit can be regulated to suit the work being done by various methods of control, these methods differing according to the make of the equipment. There are three types of equipment on the market, which may be described as the constant-voltage, the variable-voltage, and the constant-current types:

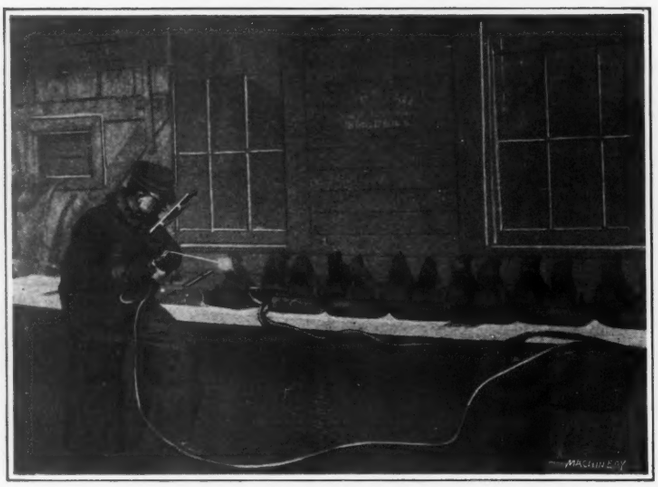


Fig. 25. Reclamation of Worn Freight Car Knuckles

The constant-voltage type is a motor-generator set that takes power from the shop mains and delivers on the generator end a practically constant low voltage. A resistance ballast is used between the generator and the welding arc to determine the current and to limit the current at short-circuit. The power used in the resistance ballast is, of course, wasted. In stationary outfits, the low-voltage direct-current power is carried over the shop on heavy cable to the welding outlets.

The variable-voltage type is a motor-generator set in which the voltage supplied by the generator is variable, the generator delivering practically the voltage required by the arc.

The constant-current type is a motor-generator set that takes power from the shop mains and delivers on the generator end the current required for welding without the use of resistance ballast. The inherent characteristic of the generator is such that the short-circuit current is limited without the use of resistance ballast. Inductive ballast is used to stabilize the arc. This type of equipment is usually furnished in the portable type, and the low-voltage distribution system is thus eliminated. The motor is fed directly from the shop lines. The constant-current type of welder has been developed to meet the demand for an outfit that will produce a welding current

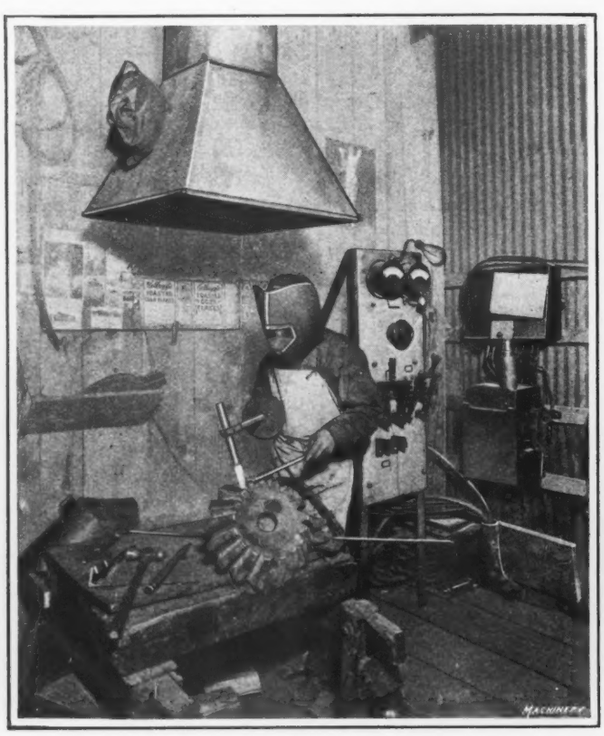


Fig. 26. Broken Teeth in Bevel Pinion repaired

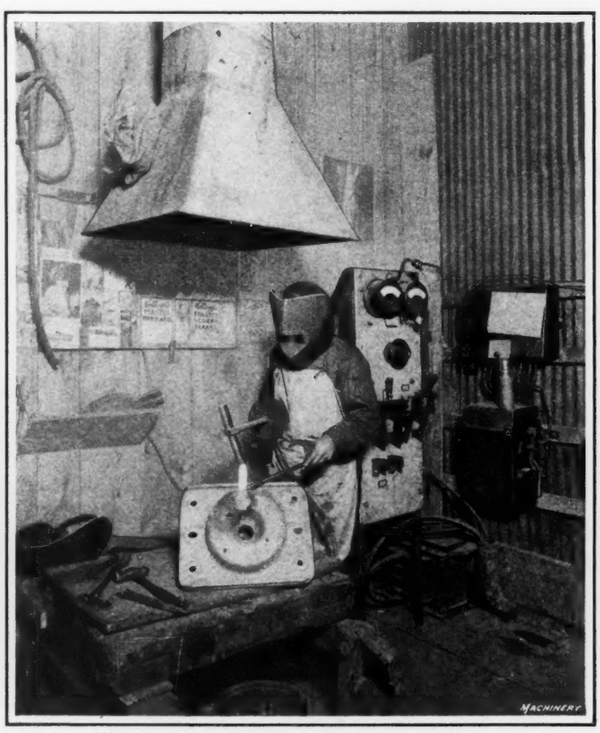


Fig. 27. Filling in Blow-holes in Castings by Electric Arc

of constant value, regardless of the length of arc, and that can be installed at any desired location in the shop. Machines of this type are so made that the voltage varies automatically as operating conditions change, thereby keeping the current at the predetermined amount. Provision is also made to adjust the current to different values to suit various classes of work, thereby making apparatus of this type suitable for all kinds of shops. These machines may be connected to the shop circuit like other motor-driven devices.

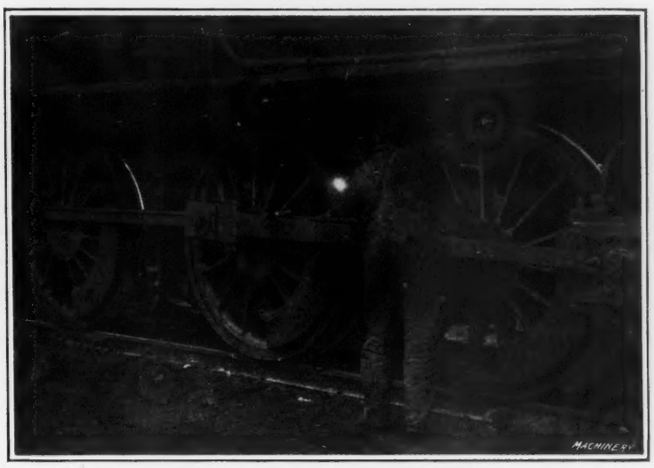


Fig. 28. Building up Flat Spots on Locomotive Drivers

As examples of constant-voltage machines may be mentioned the generators of the Wilson Welder & Metals Co., which are wound for voltage of 35 volts, and those of the General Electric Co., which are wound for voltage of from 60 to 75 volts, it being in no case necessary to have a generator of higher voltage than this for welding.

The Lincoln Electric Co. supplies a variable-voltage equipment. At the instant of short-circuit, the voltage is very low—from two to three volts. When the operator is welding with the metallic arc the voltage across the arc is from twenty to twenty-five volts. Carbon electrode welding requires from thirty-five to fifty volts. When the machine is running, but the operator is not welding, the voltage may be from sixty to eighty volts. The C & C Electric & Mfg. Co. makes a constant-current machine, working on the principles outlined

Single-operator units of either type may be made portable. Large constant-voltage multiple-operator units must be located at definite points, although the welding panels may be made portable if the low-voltage distribution system is heavy enough to prevent interference between operators due to line-drop.

Dynamotors

The C & C Electric & Mfg. Co. uses, in some cases, a dynamotor instead of a motor-generator set on direct-current circuits. The dynamotor is a single machine, duplex-wound, combining the functions of both the motor and the generator. Dynamotors are somewhat lower in price than motor-generator sets, and are lighter and therefore desirable for portable outfits.

Examples of Welding Equipment

Figs. 3, 4, 5, 6 and 8 show a number of welding outfits. That shown in Fig. 3 is a motor-generator set of 500 amperes capacity, the control equipment being shown in the background. This set is made by the General Electric Co., Schenectady, N. Y. In Fig. 4 are shown two outfits made by the Lincoln Electric Co., Cleveland, Ohio, together with the control switchboard. A welder is shown at work, this illustration giving a clear idea of the conditions under which the work is done. Two portable equipments are shown in Figs. 5 and 6, the former being the product of the C & C Electric & Mfg. Co., Garwood, N. J., this particular outfit being wound for operation on a direct-current circuit; outfits wound for operation on alternating-current circuits are also supplied, the latter being made by the General Electric Co. These portable outfits consist of motor-generator sets with switchboards mounted directly on a truck. Fig. 8 shows a complete installation made by the Wilson Welder & Metals Co. It will be seen that there is one motor-generator set and six separate control panels, one for each welding circuit.

Switchboards

It is generally preferable to have the apparatus for controlling the motor and generator on a separate panel from the welding control circuits, as this makes it possible to install the welding machine with its panel in a separate room, if desired, and to mount welding station panels near the work. In this way, the distribution circuit can be run from the control panel throughout the shop, and the welding panels can

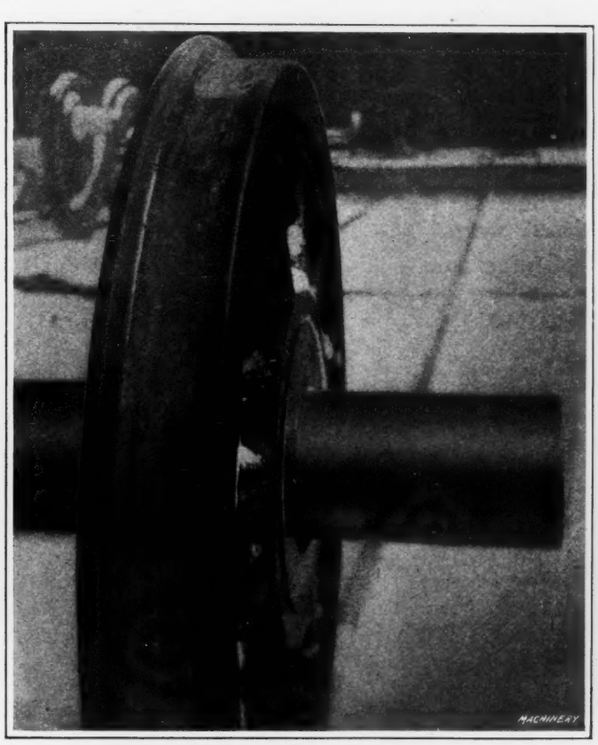


Fig. 29. Locomotive Trailer Wheel with Flat Spot Ready for Welding

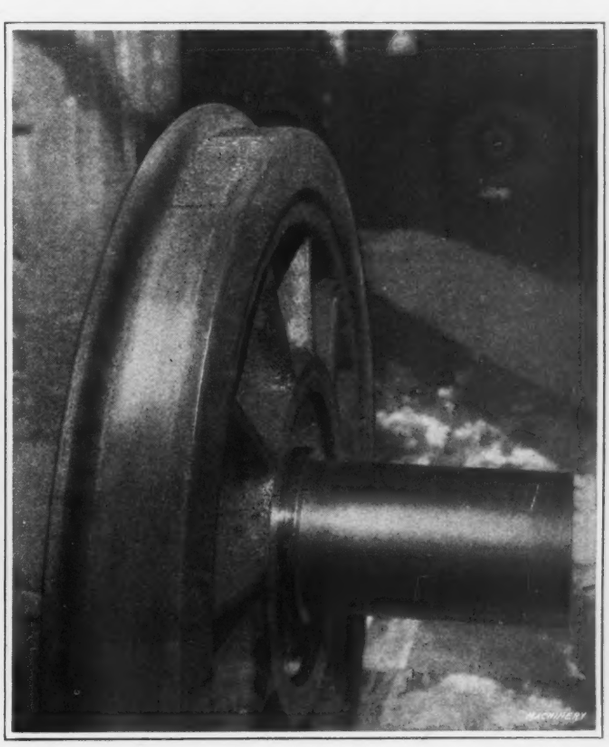


Fig. 30. Locomotive Trailer Wheel with Flat Spot built up by Arc Welding

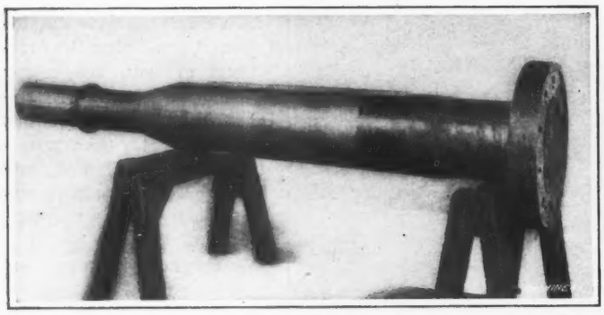


Fig. 31. Ten-inch Electric Generator Shaft machined 1/16 Inch too Small in Diameter

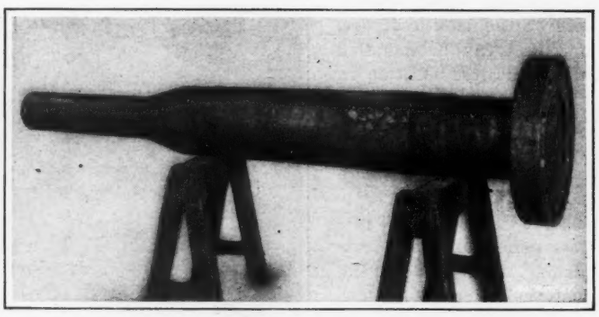


Fig. 32. Same Shaft as shown in Fig. 31 after being built up by Welding, Ready to be machined

be tapped from this circuit the same as motors. Fig. 7 shows a diagram of connections for a C & C Electric & Mfg. Co.'s constant-voltage outfit. This gives automatic control of the welding current at all times. When the operator brings his electrode into contact with the work, the current is limited by all the resistance in the circuit, but when he draws his arc, the automatic contactor cuts out part of the resistance and allows the current to come up to the amount required for welding. Upon stopping work, the contactor drops back and all the devices are ready for further operation without attention. Should the operator attempt to use more current than has been determined to be proper for the job, a self-closing circuit-breaker acts immediately, interrupting the circuit, but permits resumption of welding, without it being necessary to close the circuit breaker manually.

The control of the welding circuit differs, as mentioned, according to the make of the welding outfit. In the General Electric Co.'s outfit, the control consists of a main generator panel and a separate panel for each operator. Double circuit panels are also provided, so that two operators can work from the same panel through separate equipments. If the circuits are duplicates, a set of switches can be provided for connecting the entire capacity of both circuits to one electrode. This is sometimes done for carbon electrode welding or cutting. A convenient type of switch is provided for adjusting the resistance in series with the arc and providing a number of steps in changing the current. Means are provided so that a large number of operators can work from the same machine, since trouble on any one operating circuit is localized and does not affect any other. Circuit-breakers are mounted on the main generator panel, which will open the circuit in case of a short-circuit in the cables or in the event of an excessive load being thrown on the generator. Fig. 9 shows the connections of a G.E. arc-welding control panel for a generator and one welding circuit, while Fig. 10 shows the connections of an auxiliary arc-welding control panel for one welding circuit.

Fig. 33. Worn Valve-yoke Stem built up by Welding, Ready for Machining

The Wilson Welder & Metals Co. has a special constant-current control panel for welding and cutting which makes use of a so-called "carbon pile" held under compression by one or more helical springs, the pull of which is opposed by a solenoid through which the current to be regulated is passed. This control outfit was described in detail in the February, 1917, number of MACHINERY.

A large foreign concern developed a machine some time ago for utilizing the welding energy without losses. This machine generates energy at the required voltage directly, and always supplies current of the same value, notwithstanding considerable resistance fluctuations in the welding circuit. At the same time, a steady arc is obtained. The heat flowing to the article welded is, therefore, quite constant, which is of importance for satisfactory welding. The peculiar property of this welding generator of giving a constant current with a variable resistance is obtained by means of a threefold field excitation, as may be seen from the diagram of connections in Fig. 11. One field winding is a differentially connected series winding, the second is a shunt, and the third, a separately excited winding which receives

Fig. 34. Welding a Lug to End of Steel Forging for a Center

Fig. 35. Manufacturing Gear Guards from Sheet Steel by Electric Welding

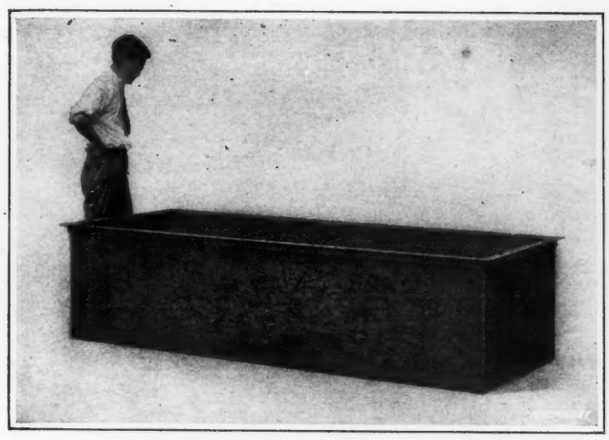


Fig. 36. Electrically Arc-welded Plating Tank

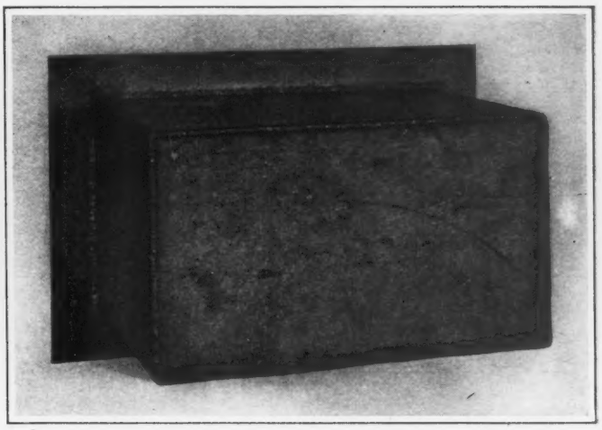


Fig. 37. Electrically Welded Tank, showing Character of Welds

current from a special circuit with a constant voltage. Any given welding current most suitable for the work can be obtained by adjusting the regulator for the separate excitation. The voltage of the machine may be altered by the regulator for the shunt excitation. Thus a finely graduated adjustment of the current and voltage may be obtained by suitably arranging the two regulating resistances, so that the machine can be adapted within wide limits to the requirements for the welding work in hand.

Fig. 12 illustrates the value of the current for the machine adjusted for a welding current of 150 amperes. It shows clearly that the welding current remains constant even when the arc resistance varies from zero (*i. e.*, short-circuit) to 0.5 ohm. Only after attaining a still higher resistance does the current begin to fall gradually.

Operation of a Welding Outfit

As mentioned, the control of the General Electric Co.'s constant-voltage arc-welding outfit consists of a main generator panel and a separate panel for each operator. The dial switch on the auxiliary panel controls the amount of resistance in series with the arc and, therefore, controls the current used. This is regulated as required by the work to be done. The automatic control equipment gives thorough protection to the generator without affecting other operators whose welding circuits may be connected to the same generator. This equipment consists of a protective relay controlling a shunt contactor in the welding circuit. The relay is provided with an oil dashpot and, therefore, will not operate on momentary fluctuations of current. Before starting the arc, the operator sets the dial switch for the amount of current required for the work, so that, on starting, the circuits are in the normal running position. Thus there is no necessity for having any relays or switches open or closed, or in any way disturbing the electrical circuit in order to weld.

However, if the operator leaves the electrode in contact with the work too long, or takes too much current after having drawn the arc, the protective relay opens the contactor exciting coil, which, in turn, opens the welding circuit. In order to resume operations, it is necessary only for the operator to lift the electrode, breaking the circuit, whereupon the relay drops out, closing the contactor and restoring the circuits to the normal operating condition. This system gives complete protection to the generator and assists the operator by making it unnecessary for him to leave his work to close the circuit-breaker, or to lose time in any other way. Other operators, whose welding circuits are connected to the same generator, are not involved in any way, since this protection affects only the circuit in trouble. In case of an extremely heavy load or a severe short-circuit in the cables, the circuit-breakers on the main panel will open the generator circuit.

Aside from the use of judgment in the application of the electric arc-welding process, there are three rules that the operator must observe in order to obtain the best results in welding: (1) Hold a short arc. (2) Use a low current. (3) Always work on clean metal.

Electrode Holders and Cable

The electrode holders are generally designed in a simple manner mechanically, and provided with means for holding the electrode firmly. Generally a new electrode is held in the holder about half way down on the electrode, and moved out as required. The holder is insulated where the hand grips it, and provides for the connection from the source of current supply to the electrode. In the design of electrodes, small, flimsy, or light projecting parts should be avoided, as they are likely to be broken off or bent. It is highly important in the design of a holder to make it fool-proof to the extent that it is practically impossible to burn or damage it by accidental contact, so that it would become inoperative. Fig. 13 shows a recent design of electrode holder.

Fig. 38. Welding Oil Stills by Electric Arc

The cable leading to the electrode holder should be exceedingly flexible, so that the operator has absolute control of the holder and the arc. The cable generally specified is extra-flexible, stranded, dynamo cable, with varnished cambric insulation, covered with weather-proof braid. The following sizes of cable have been found suitable: Up to 200 amperes, size of cable, 225/24 of 90,000 circular mils; from 200 to 500 amperes, size of cable 375/24 of 150,000 circular mils; from 500 to 1000 amperes, size of cable, 650/24 of 260,000 circular mils. The figures indicating the size of the cable designate

Fig. 39. Welding Air Compressor Intercoolers by Electric Arc

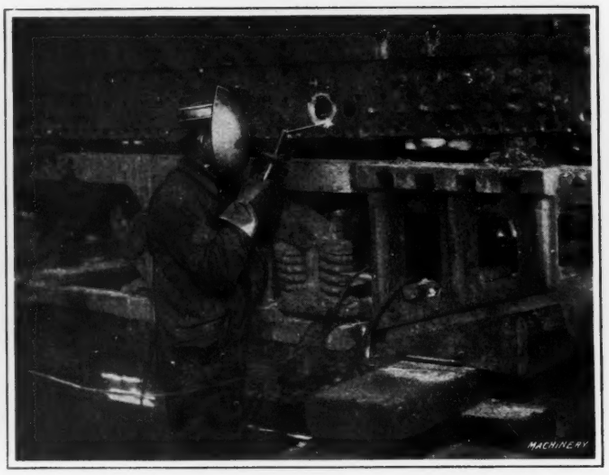


Fig. 40. Repairing a Locomotive Boiler by Arc Welding

the stranding; for example, a 225/24 cable is one formed by stranding together 225 wires, each of which is No. 24 Brown & Sharpe or American standard wire gage.

Striking Arc and Handling Electrodes

The arc is established by momentarily touching the electrode to the work and then withdrawing it a short distance. Practice is necessary in order to manipulate the electrode so as to maintain an approximately constant length of arc while welding. Skill in this respect is of importance to a welder, as variations in the length of the arc, in strictly constant-voltage machines, cause corresponding variations in the amount of current, which, in turn, causes variations in heat and thus in the quality and uniformity of the metal in the weld. As the carbon arc is considerably longer than the metallic arc, it is more stable and less likely to break. The metallic arc is very short, being only from 1/8 to 1/4 inch long. After the arc is established, it can be moved about along the work by merely moving the electrode. The carbon electrode is frequently used for preheating such work as castings, the preheating being extended a distance from the weld by keeping the electrode moving rapidly enough so as not to melt the work. In welding with the carbon electrode, the operator holds the electrode holder in one hand and feeds the rod of filling material into the arc with the other. The filling material is melted into the weld and mixes with the molten material of the work, forming a homogeneous mass of metal in the weld. As mentioned, the carbon arc is largely used for building up worn surfaces, owing to the rapidity with which a large amount of metal can be built up; but there are certain advantages in using the metal electrode for some classes of work, as will be mentioned in connection with the application of electric arc welding to railroad shops.

When heavy plate is welded with more than one layer of metal in the joint, the operator should brush off the layer of oxide from the metal with a stiff brush, commonly known as a "casting brush" or a "painter's wire brush." This is done in order that the metal throughout the weld may be free from slag and oxide. If this is not done, there will not be a proper adherance between the two layers of metal, which may result in a leaky or spongy weld. In work on tanks that will contain liquids under pressure, and where a homogeneous weld free from blow-holes is necessary, a short arc and slow speed in the work, with a comparatively low current, the metallic electrode being used, will insure the best results.

Protection of Operator

Owing to the intensity of the light and heat rays from the arc, careful protection of the operator's hands, face, and eyes is extremely important, especially in the case of the carbon arc, where the volume of light and heat is very great. Heavy gloves serve to protect the hands, while for the face, some form of shield held in the hand or supported from the head is used. This is provided with an opening filled with several thicknesses of ruby or blue glass, which affords protection to the eyes and still permits the welding operation to be closely followed. A satisfactory shield for building-up operations can be made of a soft pine board or sheet metal with a small slot in it for the protective glass. Firebox work requires a head shield which should be made of hard fiber. The color combination in the protective glass is of importance. Two red glasses and one blue glass or two reds and a green give good results. Special glass put out under various trade names is also satisfactory. As a rule, the operator tries several combinations until he finds one that seems to suit his eyes best. While the operator is working outside the firebox, the other men should be protected from the light of the arc by screens. Portable screens should be used where

Fig. 41. Patch riveted to Mud Ring Ready for Welding

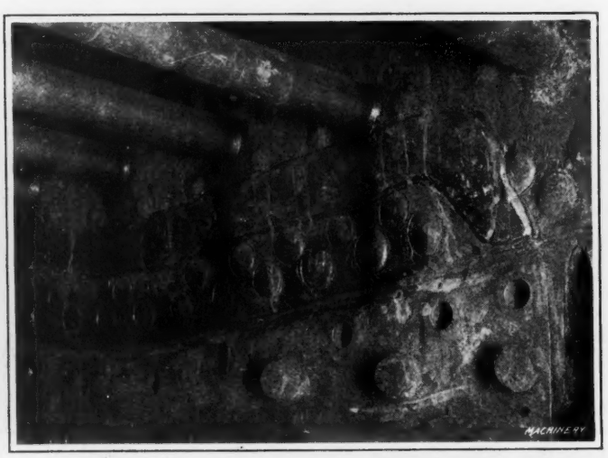


Fig. 42. Patch shown in Fig. 41 after being welded in Place

work is done on the floor. Where there is a regular welding bench, permanent curtains should be provided. The screens should always be designed to protect the crane operators from the flash of the arc. Figs. 14 and 15 show front and rear views, respectively, of two types of face shields used by the General Electric Co. A number of the illustrations in this article showing operators at work also indicate the different types of shields that are employed.

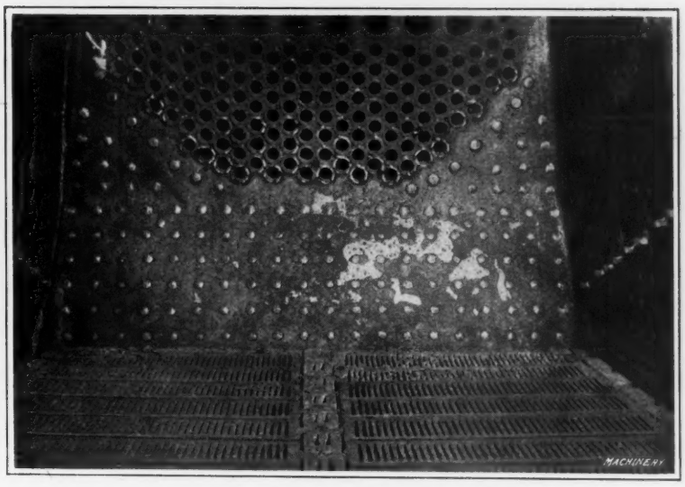


Fig. 43. Locomotive Firebox with Electrically Arc Welded Flue Sheets, Side Sheets, Flues, Superheater Tubes, and Brick Arc Studs

Capacity of Outfits

The C & C Electric & Mfg. Co., Garwood, N. J., builds constant-voltage equipments in sizes of from 300 to 1500 amperes, and constant-current machines from 25 to 600 amperes. The company recommends the constant-current type on the score of economy and higher efficiency in the welds. For large castings and forgings and, in general, for all sections of from 1 to 6 inches in thickness, machines of from 400 to 600 amperes capacity are required. Large shafting or parts of very heavy section require machines of from 600 to 900 amperes. In steel foundries, for example, machines of from 750 to 900 amperes are used, providing there is not much cutting or burning to be done. In the latter case, when heavy risers are removed and similar work is done by the arc, a capacity of from 800 to 1000 amperes will be required. The welding of sheet metal and steel plate does not require more than a maximum of 200 amperes, according to the thickness of stock used.

The General Electric Co., Schenectady, N. Y., builds outfits in capacities from 200 to 1250 amperes for stationary use, and from 200 to 400 amperes for portable use. For metallic electrode welding, machines having 200 amperes capacity are sufficient for one operator, and where a number of operators are working from one set, under average conditions, from 125 to 150 amperes per operator should be provided. For light welding by the carbon electrode, about 200 amperes is sufficient; for medium welding, up to 400 amperes; and for heavy welding, up to 500 amperes. For cutting or melting, from 300 to 1000 amperes is needed, according to thickness of metal.

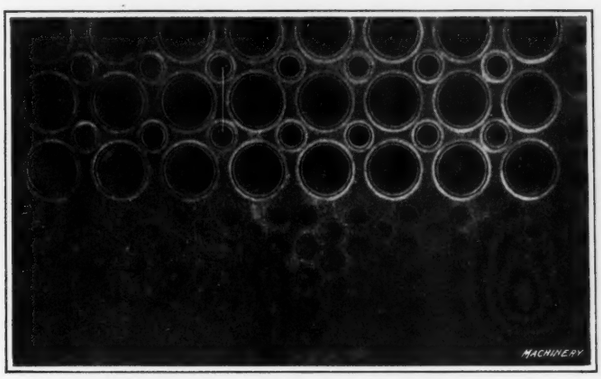


Fig. 44. Superheater Flues Ready for Welding

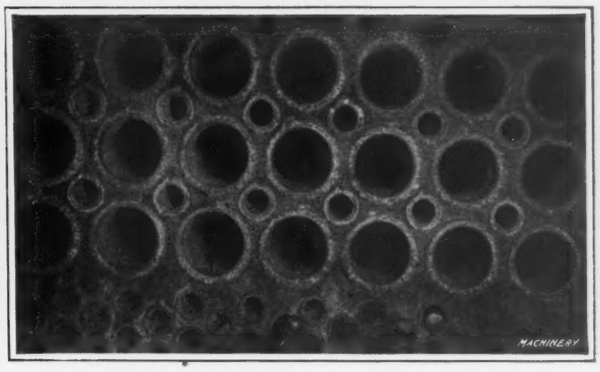


Fig. 45. Superheater Flues after Welding is completed

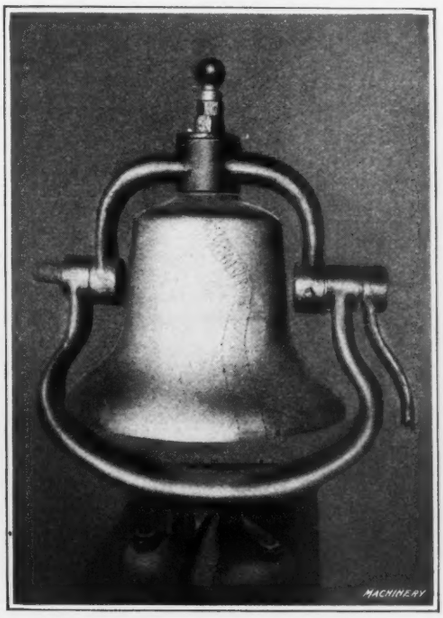


Fig. 46. Locomotive Bell welded by Arc Process

Cost of Electric Arc Welding

It is difficult to give accurate figures covering the cost of welding, whether the work be done by the electric arc or by some other method. The work varies to such an extent that it would be impossible to give the exact cost of any particular job in advance. Furthermore, the cost of the current, the wages paid, and the skill of the welder will vary. All these factors, of course, have a direct influence on the cost of making the weld. Of the three factors mentioned, the first—the cost of the current—varies between the widest limits, as wages are fairly well standardized for this work, and the time required for making the weld should not vary much where good welders are employed. The costs in the following paragraphs are figured on the basis of labor at 30 cents per hour; at the present time the cost of labor will be higher than that, plants employing arc welding as a regular manufacturing process paying good welders as much as 50 cents an hour.

The C & C Electric & Mfg. Co. furnishes the following data showing the time required for, and the cost of, a number of actual jobs done with the company's 70-volt constant-voltage arc-welding outfit, labor being paid at 30 cents per hour and current figured at 2 cents per kilowatt hour: Forged steel locomotive frame broken in two places: time, 20 hours; cost, $18.28. Welding 67 cracks in old firebox (saving over $1000): time, two weeks; cost, $52.60. Steel shaft, 2 inches in diameter: time, 1 hour; cost, 60 cents. Cutting off riser of steel casting 4 by 4 inches: time, 4 minutes; cost, 5 cents. Building up 2-inch armature shafts worn in journals: time, 3 hours; cost, $1.80. These figures, of course, include only labor and current required, and not overhead costs. As regards the comparative cost of electric arc welding and oxy-acetylene welding, it is generally conceded that oxy-acetylene welding is cheaper for the welding of steel plate thinner than 1/8 inch, but that arc welding is cheaper when the plate is thicker than 1/8 inch, and the cost is materially reduced by arc welding for plates as thick as 1/2 or 3/4 inch.

Fig. 47. Four Operators working independently from Same Generator

The Lincoln Electric Co., Cleveland, Ohio, in comparing the cost of welding with that of riveting, estimates that the ratio of the cost of labor for arc welding to the cost of labor for riveting is as 6.5 to 10. The cost of power required for arc welding as compared with that of riveting is as 1 to 2. The investment required by the arc-welding apparatus is about 25 per cent higher than the cost of riveting machinery, but this is easily offset by the lower operating and power cost.

Strength of Electric Welds

By careful selection of metal electrodes and skill in making the weld, it has been found possible to make welds having a tensile strength of from 95 to 97 per cent of the strength of the original section, but for average conditions it may be assumed that the electric arc weld has a strength of from 80 to 90 per cent that of the metal. It is possible, however, to reinforce the welded section in many instances by building up at the point of the weld, thereby making the cross-section of the weld greater than the metal itself. Electrically welded joints are stronger than riveted joints, and when the joint is hammered while hot the ductility of the metal will be increased.

Foster superheater flues made by the Power Specialty Co., and welded by the C & C Electric & Mfg. Co.'s outfit, were tested at Columbia University with a hydraulic pressure of 5500 pounds per square inch without leakage or fracture. A receiver made of 1/2-inch steel plate with 5/8-inch flat heads, all joints being welded, was tested with a pressure of 3600 pounds per square inch, without leakage or fracture.

In order to test the relative values of different kinds of welded joints, steel plate 3/8 inch thick was welded. If the original piece of steel be assumed to have a strength of 100 per cent, the electric arc-welded lap-joint was found to have a strength of 93.5 per cent, and the electric arc-welded butt-joint, a strength of 81.5 per cent. A riveted lap-joint, single riveting, had a strength of only about 60 per cent. With heavy sections like boiler plates, the strength after welding, given in the case of butt-joints, if properly made should average about 90 per cent of the original strength of the plate. The elongation in the welded material is less than in the original plate, because it is not as tenacious, but the ductility can be improved by hammering the weld while still hot, and this is frequently done on heavy sections.

In one case, 200 steel specimens welded together by the arc-welding method were tested to determine the strength of the weld. The results of these tests indicated that the elastic limit of the original specimens was 46,900 pounds per square inch and of the welded specimens, 45,600 pounds per square inch. The ultimate strength of the original specimens was 61,500 pounds per square inch, and that of the welded specimens, 48,600 pounds per square inch. These specimens were steel bars, 1 1/2 by 3/8 inch, gripped 18 inches apart. The bars tested had been beveled on both sides and welded.

Figs. 16 and 17 show two interesting examples of electric welding, the welds having been tested for strength. Fig. 16 shows a six-inch standard wrought-iron pipe on which one cap at the end and one seam at the center were welded by the electric arc. A cap was then screwed onto the other end and the pipe subjected to a test pressure of 1000 pounds per square inch, which it withstood successfully. Fig. 17 shows an 8-inch standard wrought-iron pipe welded in the same manner. Here, when subjected to an internal pressure of 800 pounds per square inch, the cap screwed onto one end of the pipe broke as indicated, but the welds did not fracture. These tests were made by the General Electric Co. Fig. 22 shows the electric welding of a steam plate for a hydraulic press. Two 3/4-inch steel plates are held with keys and the joint between them is welded. The size of the plate is 40 by 40 inches and the steam pressure is 150 pounds per square inch. Of course, the keys in this case take the main strain, as far as holding the parts together is concerned, but the welding provides for a steam-tight joint at the pressure mentioned.

Quality of Weld

With regard to the nature of the weld, the Lincoln Electric Co. calls attention to a fact that should not be overlooked, namely, that the new metal in a weld is simply metal that has been melted and cooled again, and it partakes of the properties of cast metal rather than of rolled or wrought metal. For instance, in welding two pieces of boiler plate, the weld will have nearly as great a tensile strength as the original plate, but the weld is really cast steel, and therefore has not the ductility that the rolled steel plate possesses. By the use of special welding material, however, the Wilson Welder & Metals Co. has produced welds that will bend, when tested, almost the same as wrought iron or mild steel; this has also been the experience of the C & C Electric & Mfg. Co., when using its constant-current machine and regular Swedish iron electrodes, as advocated by this company.

It has often been stated that the welds are too hard to be machined, but this is a mistaken idea. A properly made electric arc weld can be machined as readily as a steel casting or a piece of flange steel. This characteristic of the weld has made it possible to employ the arc-welding process not only for repair work, but also in regular manufacturing practice.

Tank Welding

The best method to employ when welding tanks from plates that are 1/4 inch or more in thickness is to make a lap-joint and weld at the joint on both sides. In making lap-welds, the plates are overlapped an amount about equal to that required for single-row riveting. The best way of holding the plates

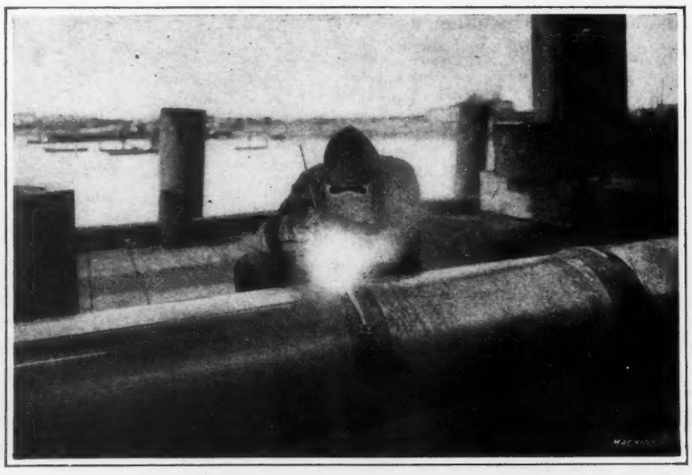


Fig. 48. Welding Bronze Sleeve of Steamship Tailshaft

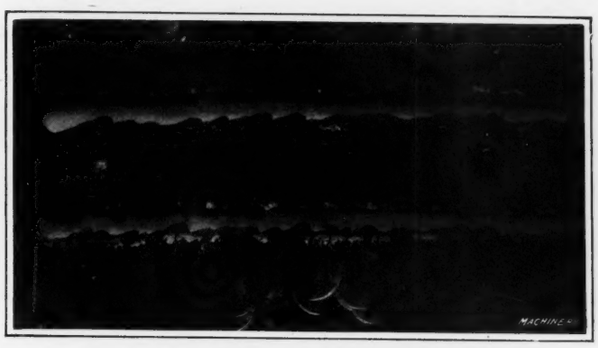


Fig. 49. Appearance of Cuts made by Carbon Electrode

together while welding is by drilling holes for bolts about 18 inches or 2 feet apart, and inserting bolts to hold the plates together while welding. When the welding is completed, the bolts are removed and the bolt holes are filled up by using the carbon arc and some filling material. The cost of making joints by lap-welding, when the preparation in handling the plates is considered, should be less than for butt-welding, because it is easier to assemble and hold the plates for lap-welding. When plates are greater than 1/4 inch in thickness, however, they may be beveled and butt-welded. For plates more than 1/2 inch in thickness, it is best to bevel the plates from both sides toward the center, forming a vee on each side, and then weld the plate from both sides. As this reduces the amount of filling by 50 per cent, the time may be considered as reduced to 40 per cent. This method can be applied, of course, only when both sides of the plate are accessible.

For plates 3/4 inch and heavier, carbon or graphite electrodes are sometimes preferable to metallic electrodes. Especially is this true when plates 1 inch thick or over are welded.

Fig. 50. A Collection of Castings with Heavy Risers which are cut off by a Carbon Arc

Applications of Electric Welding in Repair Work

Electric welding is used in the machine industries both in repair and manufacturing work. It provides a rapid and simple means for quickly repairing broken castings, so that machinery that has broken down may be rapidly put back into operation. By the aid of the electric arc, machines with broken parts may be put in running condition in a few hours, where it might require days or weeks if the parts had to be cast and machined. Fig. 18 shows a broken lathe steadyrest, and Fig. 19 shows the same steadyrest after being welded. Fig. 20 indicates the value of electric arc welding in cases of a serious breakdown. Here the arm of a radial drilling machine is broken at the post. In this case, the making of a new casting and the machining of the arm would have required considerable time. Fig. 21 shows the break welded and the drill ready for operation. In Fig. 24 is shown another large welding job in a casting that would be costly to make in the foundry and equally costly to machine. This is a bearing cap for a 500-ton punch press. The carbon arc was used in making this repair. This work was done at the Pressed Steel Products Co.'s plant with a C & C Electric & Mfg. Co.'s equipment.

Broken gears can be successfully welded with the electric arc, both in the case of broken arms and rims and broken teeth. In the latter case, of course, the tooth that has been built up must be machined. Fig. 23 shows a large spur gear with one arm broken in two places and the rim fractured in three places, which has been successfully repaired by a General Electric Co.'s equipment, while Fig. 26 shows an example of repairing the teeth in a bevel pinion with a Lincoln Electric Co.'s equipment. This illustration also shows a good form of face and head protector.

Another important field for electric arc welding is that of building up worn parts and filling in holes or defects in castings that would otherwise be scrapped. In Fig. 27 is shown an example of a casting with a large blow-hole that is being filled in and built up by using the carbon arc and a metal filling rod, so as to save the casting. In Fig. 25 is shown the reclamation of worn freight-car knuckles by building up the worn parts on the knuckles so that they can be used again. On one railroad line alone it is stated that the saving in one year in the reclaiming of freight-car knuckles that would otherwise be scrapped amounts to more than $20,000. This work is done with the Wilson Welder & Metals Co.'s equipment.

An interesting application of the electric arc is in building up flat spots on locomotive and car wheels. In Fig. 28 is shown an example of how the welding is done on a locomotive driving wheel in place on the engine. The cost of building up a flat spot amounts to about $2, and the saving is estimated at about $200. In Fig. 29 is shown a locomotive trailer wheel with a flat spot, the wheel having been prepared for welding by the electric arc. Fig. 30 shows the same wheel with the flat spot built up by welding.

Saving Worn or Wrongly Machined Parts by Building up by Welding

An important and interesting application of electric arc welding is met with in cases where parts that fit other machined surfaces are worn to such an extent that they would have to be scrapped. By building up by welding it is possible to replace enough metal on the worn surfaces so that they may be again machined to fit the parts into which they are assembled. This method is also applied in cases where shafts may have been machined too small for the journals into which they fit, or where, by an error, a boss or small projection may have been omitted in a casting or forging. The electric arc provides a cheap and simple method of correcting errors of this kind. In Fig. 33 is shown a valve yoke on which the stem has been built up by welding so that it can be again machined

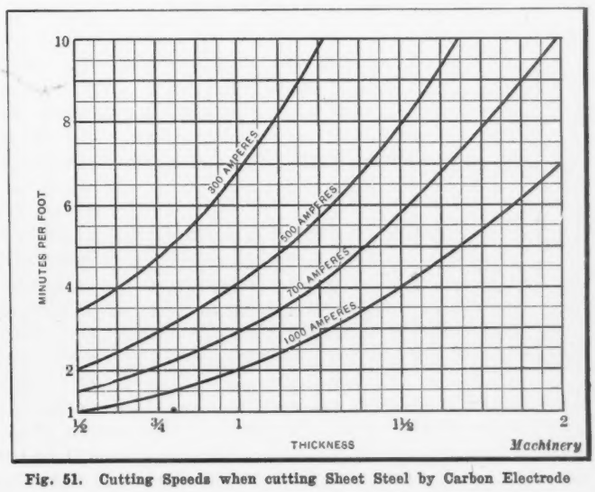


Fig. 51. Cutting Speeds when cutting Sheet Steel by Carbon Electrode

to full size. In Fig. 31 is shown an example of a 10-inch electric generator shaft which has been machined 1/16 inch too small. The scrapping of this shaft would have meant a considerable loss, but by building up on the surface that was too small in diameter, as indicated in Fig. 32, and remachining, the shaft was saved.

Fig. 34 shows an example of a forging that required a center in one end, which was not to be present in the finished piece. A lug for the center was omitted in making the forging. It therefore became necessary to weld a small punching onto the end of the forging for a center. This simple means of providing a projection on the end saved these forgings from being scrapped. Incidentally, the illustration shows the C & C Electric & Mfg. Co.'s face shield, which provides ample protection for the face and throat, as well as the upper part of the head.

Application in Manufacture of New Work

In addition to its use for repair and reclamation work, electric arc welding is employed to a great extent in the manufacture of many sheet-metal articles. Fig. 35 shows the welding of steel sheets for gear-cases, the outfit used in this case being that of the Lincoln Electric Co. The lugs on the inside of the gear-case are also welded into place. The welding of annealing boxes, oil-tempering tanks, etc., by means of the arc process has been found to be not only the most successful, but also the cheapest method of making these boxes and tanks. Fig. 36 shows a plating tank that has been electrically welded. This tank is 8 feet long, 3 feet wide and 2 feet high, and is made from 1/4-inch plate with a rim around the upper edge of 1/4 by 1 1/4 inch angle-iron. A tempering tank made from 3/16-inch sheets with a rim of 1/2-inch boiler plate is shown in Fig. 37. The size of the tank is 30 by 21 by 15 inches. The illustration shows clearly the nature of the welded seams. Fig. 38 shows some very large work being done by the arc-welding process. The work consists of oil stills at the Standard Oil Co.'s plant in Whiting, Ind., welded by the General Electric Co.'s equipment. The stills are riveted, but the joints are made tight by means of electric welding. Another example of the application of the electric arc to manufacturing work is shown in Fig. 39, where the tubes of air compressor intercoolers are welded in place at the plant of the Worthington Pump & Machinery Corporation, Cincinnati, Ohio.

Another example of electric arc welding is found in the welding of steel barrels by the Standard Oil Co., using the C & C Electric & Mfg. Co.'s equipment. In these barrels, the longitudinal seam is welded electrically. The bulge of the barrel is then obtained by hydraulic pressure, showing that the efficiency of the weld is high and that the heat of the arc has not affected the strength of the steel to any appreciable extent.

Application of Electric Welding to Railroad Shops

There are a great number of instances where electric arc welding may be used to advantage in railroad shops. In fact, the railroad shop offers one of the greatest opportunities for the application of the process. It is used to a large extent in many shops in building-up operations. Practically every steel casting on a locomotive is subject to wear at several points. Where worn, the metal may be built up again, by means of the metal electrode process, both cheaply and rapidly. Most of these building-up operations are done with a 5/32- or 3/16-inch electrode. The use of smaller electrodes is not economical, owing to the slow progress of the operation. The use of larger electrodes is inadvisable on account of the difficulty in controlling the metal. Metallic electrodes should be used in preference to carbon electrodes for welding of this kind, for the following reasons: (1) Steel castings welded with a carbon arc would have to be annealed, which entails additional cost and delay. (2) The metal can be deposited at the exact place where it is required more accurately by the metal electrode process than by the carbon electrode method; and, therefore, while the carbon arc process is somewhat more rapid than the metallic arc method, the time saved in the welding operation by the carbon arc would be lost in the machining operation on account of the inaccuracy of the location of the deposited metal. (3) The operator requires less skill in the use of the metallic arc than in the use of the carbon arc when the process is used for building-up operations; when applying metal with a metallic electrode, the operator is forced to move along as fast as the metal is deposited; with the carbon electrode, he may dwell longer, but is, however, likely thereby to produce a burned spot. (4) Hard spots are not produced when the metal electrode process is used for building up.

Flue Welding

Electric arc welding is also frequently used for welding in the firebox and for flue welding. The process recommended by a sub-committee of the Association of Railway Electrical Engineers is as follows: Welding in the firebox should be done with a 1/8- or 5/32-inch electrode. The best metal is obtained in the weld with these sizes. The amount of heat is as small as can be economically used. It is evident that, owing to trouble from expansion and contraction, the quantity of heat it is possible to use in welding flues or firebox sheets is limited. The ideal preparation of a set of flues for welding is as follows: (1) Put flues in exactly as if they were not to be welded. (2) Fire the boiler, or, better still, send the engine out for a run. The object is to burn the oil out from under the beads of the flues. (3) The flue sheet should then be brushed with a stiff wire brush or sand-blasted. The object is to eliminate, as far as possible, the scale of oxide on the flue sheet and flues. Iron oxide is not a good conductor of electricity and causes difficulties with the arc, which, in turn, may produce a poor weld.

The welding of 2-inch flues is best done with a 1/8-inch electrode. On sand-blasted flue sheets, from 90 to 100 amperes is enough current. Flue sheets that have a thick coat of oxide require from 120 to 130 amperes with this size of wire, and the weld will not be satisfactory. Five-inch flues should be welded with a 5/32-inch electrode and with from 120 to 140 amperes, depending upon the condition of the flue sheet.

Cracks or Seams

Cracks and patch seams offer the most difficult problems to the operator. A crack should be located and a ½-inch hole drilled at least two inches beyond each end. The edges of the crack should then be beveled so that the operator can reach them to make the weld. On horizontal cracks, the lower edge does not need to be beveled, but should be chipped to produce a square edge. The upper edge should be beveled at least 45 degrees. Vertical cracks should be beveled from 30 to 45 degrees on each side. The less material removed from the crack the better. All welds should be made with the least possible amount of metal between the edges of the original material.

If the crack or seam is a long one, the metal should be put in alternate sections of from four to six inches long. The operator should put one layer of metal in each of these alternate sections, starting near the center of the seam or crack. The open sections can then be filled, starting at the coolest point. Successive layers of metal can then be applied until the seam is completed. Wherever possible, at least 30 per cent of reinforcing should be applied so that the cross-section through the weld is 30 per cent greater than the section of the original plate. After each layer of metal is welded into the seam, it should be thoroughly brushed with a stiff wire brush to remove as much of the oxide as possible. Where the sand-blast is available and can be used on the job, the results will justify the expenditure of time necessary to clean the metal between the layers. The same general care should be taken in the welding of locomotive frames as in the case of the boiler plate of the firebox.

A number of examples of the application of electric welding to railroad work are shown in Figs. 40 to 47, inclusive. Fig. 40 shows the repairing of a locomotive boiler at the Toledo & Ohio Central shops at Bucyrus, Ohio, the metallic arc with the General Electric Co.'s outfit being used. Figs. 41 and 42 show a patch 10 inches wide and 5 feet long being riveted to the mud ring of a locomotive on the Central Railroad of New Jersey. The vacant space indicated is left for welding. Fig. 42 shows the patch after being welded in place. Figs. 44 and 45 show the application of electric welding of superheater flues on the Atlantic Coast Line, the work shown

in Figs. 41, 42, 44 and 45 being done by using a C & C Electric & Mfg. Co.'s equipment. Fig. 44 shows the flues ready for welding, and Fig. 45, the job completed. Fig. 43 shows a locomotive firebox with electric arc-welded flue sheets, side sheets, flues, superheater tubes, and brick arc studs, indicating the wide range of work for which the process is adapted.

Welding Non-ferrous Metals

An interesting application of electric arc welding is that of welding locomotive bells. Fig. 46 shows the cracked bell repaired, the dotted lines indicating the weld. The cost of this welding is $2.60, and the saving by welding is $7.50. This example of electric welding is especially interesting on account of the fact that bell metal is being welded. Fig. 47 shows the welding work on the bells being carried out. The work is done by the carbon arc, using a filling-in rod. Other welders are also shown at work using current from the same generator, but each welder having a separate control panel. The control equipment shown in the background is that of the Wilson Welder & Metals Co.

Another example of the welding of non-ferrous metals by the electric arc is shown in Fig. 48, where a General Electric Co.'s equipment is used for welding bronze sleeves for a steamship tailshaft by using a bronze electrode. The shaft is 13 inches in diameter and the sleeve is welded together from three sections, the total length of the sleeve being 13 feet. The metal being welded is 3/4 inch thick; the edges are beveled preparatory to welding.

Cutting or Melting Metal with a Carbon Electrode

When cutting or melting metal with the electric arc, a carbon electrode must be used. The electrode is operated in a manner similar to that used when employing a gas torch for metal cutting. The electric arc actually melts the metal away, it being held at one point until fusion occurs and the melted metal runs off, after which the arc is slightly advanced, and in this way a path through the metal is gradually melted. The width of the groove cut depends upon the size of the electrode used and on the skill of the operator in advancing the electrode along a straight line. The cut will be slightly wider than the diameter of the electrode, and is also wider for thick sections than for thin ones, as the electrode will melt away more metal when the arc has to be played on the bottom of the cut. It is not possible to obtain very smooth edges of the cut on account of the fact that some parts of molten metal will not run away evenly, and also because the arc has a tendency to jump from one point to another, causing an uneven cut. Fig. 49 shows an illustration of cuts made by the carbon arc in 1/2-inch boiler plate. For cutting steel plate where a smooth edge is required and much cutting is to be done, the oxy-acetylene process is conceded by the makers of arc-welding apparatus to be preferable, because a smoother cut is obtained. For cutting cast iron, however, the electric arc is equal or superior to the gas torch, and for cutting off heavy risers in the foundry on both steel and iron castings, and for cutting up scrap where a ragged edge is of no importance, the electric arc is used to advantage. Fig. 51 shows a diagram of approximate cutting speeds for different thicknesses of sheet steel and for various current values. The cutting speed is lower than is possible with the gas process, which burns away the metal rather than melts it, but with a reasonable power rate, the cost of cutting by the arc is much lower than the cost of cutting by means of gas, in a great many cases. Where the metal is rusty or where blow-holes are encountered in steel castings, the electric arc will cut the metal with equal ease, while the gas process cannot be employed in cases of this kind. The metallic electrode cannot be used for cutting metals.

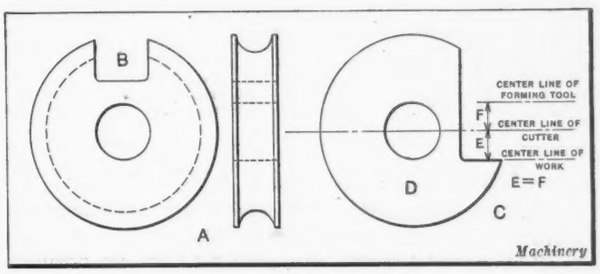
Fig. 50 shows a number of steel castings in the shops of the Marion Steam Shovel Co., showing heavy risers which are to be cut by means of the electric arc.

In the preparation of this article on electric arc welding, the writer has been assisted by the C & C Electric & Mfg. Co., the General Electric Co., the Lincoln Electric Co., and the Wilson Welder & Metals Co., to all of whom he is indebted for the courtesy shown and the assistance they have rendered.

MAKING A FORMING TOOL

BY FRED J. MILLER [1]

Many articles have been published in technical journals explaining how to develop the curves of a forming tool that when set either above or below the center of the work will reproduce the form of the templet made to fit the work. All this is entirely unnecessary if we remember that, when finishing a forming tool in the lathe, the shaping tool should be placed as much above the center of the cutter being turned as the cutting edge of the cutter will be below the center of the work when it is in use. This will automatically modify the form of the cutter and will do it with absolute precision without any necessity for developing curves or for making any calculations whatever. In the illustration at *A* is a forming cutter, and if we mill a gap in this cutter as shown at *B*, the outline formed by the intersection of this gap with the periphery of the cutter will be the same at both sides of the gap. This principle when applied to the forming of the cutter is shown at *C*, where *D* is the cutter, set with respect to the center line of the work as shown; cutter *D* is supposed to have been formed by a forming tool placed on the upper line indicated, and this forming tool should be the exact shape of the work to be produced. It may thus be made from the work itself or from a templet prepared for the purpose, which represents the form of the work and may be of thin steel clamped in a suitable holder.



Position of Cutter Forming Tool

This same principle can be and has been applied to fly cutters such as are used for temporary jobs in cutting gears, etc., in a milling machine; clearance is obtained by forming the cutter when its face is set a certain distance back of the center line, the cutter being afterward used with its face set the same distance ahead of the center line. The same principle is also applicable to form milling cutters which have what is known as "rake" in the cutting teeth. Not only is it true that by this method a great deal of time and labor are saved in developing curves, making templets, forming tools, etc., but much better and more accurate results are obtained than can possibly be obtained by the method of calculation and development.

* * *

THE LIBERTY MOTOR

The recently designed "Liberty" motor is shown by tests to be an especially efficient engine, and it will be used on all U. S. airplanes and motor trucks; the twelve-cylinder engine has surpassed the expectations of its designers. While this motor will be made with four, six, eight and twelve cylinders, the design allows the maximum interchangeability of parts; thus the valves, camshaft drive, pistons, single cylinders, and many other parts can be used on any of the four models. A twelve-cylinder engine can be made up from eight-cylinder parts with the addition of the extra cylinders, etc., and the crank-case and crankshaft. In the same way a six-cylinder engine can be made up from four-cylinder parts with ease. Although this motor has been developed largely by two engineers, one connected with the automobile industry and the other with aviation, it is a combination of the best features of engine design, both American and foreign. It has been so designed that it can be manufactured cheaply in great quantities, and differs from the best foreign engines in the elimination of the great amount of hand work the latter require.

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We solicit contributions from practical men on subjects pertaining to machine shop practice and machine design. All contributed matter published exclusively in MACHINERY is paid for at our regular space rates unless other terms are agreed on.

ORGANIZATION AS AN ASSET

It is said that Carnegie, when asked what would happen if his mills should be destroyed by fire, or if he should suddenly lose all his material wealth, answered: "If I had my organization intact, I could regain it all in ten years." No doubt the remarkable success of Carnegie as a steel manufacturer was partly due to his realization that the physical assets of his business in buildings and machinery were but a minority of the factors that contributed to the building up of his fortune, and that the important one was an organization of men properly trained and willing to cooperate toward a common end. Many manufacturers lose sight of this fact. They appear to look upon the machinery and the buildings as the main assets of their business, and prize but lightly the organization that stands, or should stand, behind the physical assets. A strong man may be able to manage successfully an organization that is only loosely tied together; but as soon as he hands the reins over to someone without executive ability, the whole organization may go to pieces. Everyone who has observed the history of industrial business has seen examples of this. It is of the highest importance, therefore, to the permanency of any business that the organization be such that it can continue in the absence of any one man, and also such that the people who compose it are so closely tied to the organization on account of the appreciation of its ideals and the things that it stands for, that they do not scatter when some break occurs. Recently we saw an example of an excellent organization that was greatly impaired because one executive left and took with him a dozen other of the best men, forming a new concern; and he was able to do this because, in the old organization, nothing had been done to tie those men to the enterprise either by sympathy, cooperation or otherwise. As to physical assets, the old company is as well off as ever. All its machines and all its buildings are there; but the men who could get the best results out of the machines have gone, and a considerable part of the assets has gone with them.

* * *

IMPORTANCE OF MECHANICAL TRAINING

The European war has demonstrated the vital need of machinery and mechanical training in carrying on the conflict. We know that the mechanical engineer is the moving spirit of our modern life, in which machinery plays so important a part; but the effect of the training received by the mechanical engineer on his mental attitude is not so fully appreciated. As a result of his training and experience, he has learned to reason straight, to separate cause from effect, and to accept no effect without a cause. He has become imbued with the spirit of cooperation, and therefore is liberal minded. The training of the mechanical engineer should make him broad and constructive, while the training of some professions often tends to produce opposite results.

We venture the prediction that in fifty years the so-called classical education now often inflicted on young men will be greatly modified. Instead, they will be trained to think and act. Culture for culture's sake will be at a discount. The change will come because of greater liberality and democracy and the elimination of caste. The training received by the mechanical engineer should fit him for any business activity; that is, his educational foundation is a basis on which any business man may work effectively. Engineers will be trained not merely to be engineers, but to be business men having the capacity to grapple with the mechanical problems incident to manufacturing, railroading, transportation, municipal government, etc. The prime cause of much inefficiency in municipal government, as well as in business generally, is that the men at the head do not think straight and have little capacity to organize and direct.

* * *

SIMPLICITY OF FASTENING DESIGN

Machine designers often miss a golden opportunity for saving in the cost of manufacture of details by being too careful in proportioning the fastening details. It is not uncommon to find a machine well designed in all its essential mechanism which requires a large variety of screws, studs and bolts to hold the parts together. The screws may have been carefully selected with due consideration of their respective stresses and functions, but that scrupulous care may have resulted in carrying out the design with too little regard for the cost of production. It might have been better, from the manufacturing standpoint, to have made some of the screws larger than actually required for strength, or to have used two small screws in place of one large one so that as many as possible could be of one size and type. Thus time would be saved in drilling and tapping, and less variety of screws would be required in stock.

An eighteen-inch engine lathe is being built in which the fastening screws, with a few exceptions, are ⅝ inch diameter and of the same length. In some places, of course, a ⅝-inch screw is too large, and in others it is necessary to use two screws instead of one. Some holes have to be drilled and tapped deeper than is really necessary; but the gain outweighs the loss. By standardizing to one diameter and length of screw only, much time is saved in machining and assembling, and the job of making and keeping stock is simplified.

Substantial economies have been effected in the manufacture of typewriters by standardizing machine screw body sizes and heads and by eliminating many odd shapes and lengths. Instead of using thirty different screws in a carriage, only seven are used in the same part of a new machine. The same company has also discontinued using some gages of sheet metal stock and now uses as few as practicable. In these times, when it is extremely difficult to get anything but standard sheets from the mills, it is highly important that the use of odd gages be avoided; but if their use can be avoided in abnormal times, why not always in the interests of simple stock keeping and efficient manufacture?

Bolts fitted in reamed holes rarely, if ever, require hexagon or square heads. The fit of the body in the hole should be sufficient to resist the torsion of the nut when tightening or loosening it, but the practice of using forged hexagon head bolts is general in locomotive building and repair shops. Considerable saving can be made by using round head bolts with narrow shoulders under the heads. The height of the head need not be more than three-fourths the body diameter. Bolts of this shape can be turned from bar stock when needed for quick repairs.

TOOL DESIGN IN THE MANUFACTURE OF MUNITIONS

BY D. B.

Not many months ago the writer was a toolmaker in a watch factory that had turned its plant over to the making of time-fuse parts. The work was of unusual interest on account of the numerous accurate gages, jigs, fixtures, and special machines that had to be designed and built. It was a line, in fact, that put to the test all the skill acquired in sixteen years' experience as a general machinist, tool-, die-, and gage-maker. In love with the work and with no reason to complain of conditions, the writer might have been there yet had not one of those pests that occasionally trouble the best of us—a tool thief—gone off with one of his pet tools. To the layman this might be passed over lightly as a matter of only a few cents, but to the real toolmaker it is a most serious matter. So when a second tool was missed, "wanderlust" seized the writer, with the result that he answered an advertisement for tool designers on time-fuse parts. As the place was near by, the writer was soon on his way, although his previous efforts to get on to the board with various concerns were unsuccessful, notwithstanding the fact that he had had some night-school and correspondence-school work. In the interview that followed, the superintendent said that he wanted a designer, a man of ideas, rather than a draftsman, but he finally decided to give the writer a trial even though he had no drafting-room experience.

The plant he now entered had all new equipment, which had cost close to a million dollars. Its drafting department for nine months had been in charge of a draftsman who had been paid about $30 a week. He was a good draftsman but had no shop experience, which is absolutely essential to a thoroughly efficient tool designer; yet he had been put in charge of the most important and vital part of the plant. The result was that some of the tools were too complicated and costly, as well as inefficient for the work for which they were intended, while other tools were as crude and elementary as if they were designed for only a dozen pieces rather than for the thousands they were expected to handle. To make matters worse, practically all the tools had been built in quantities that had been estimated as sufficient to finish the contract, or were in process of construction at the time the writer was employed. Thus the design of new tools and the redesign of such as could be made to answer the purpose meant the scrapping of thousands of dollars' worth of tools, jigs, and fixtures; but it was done, and results proved that it paid.

Before this was done, however, it was necessary to reorganize the drafting department, which consisted of about half a dozen draftsmen, none of whom had had shop experience along toolmaking lines. They were men with technical education and a knowledge of drafting, and were slow to grasp new ideas or to originate such as could be put to practical use, and so required constant attention and instruction on every detail.

The drawings were being made on detail paper and turned over to a tracer to be inked in on tracing cloth, and this took so much time that it often required several days to get out a comparatively simple drawing. Realizing that the drawings would only be used for a short time, or until the tools were made and in use, and were not likely to be required for a permanent record over a course of years, the writer decided to eliminate the tracing as far as possible. Yet, as a number of blueprints were required for use in the various tool shops engaged on work for the plant, it was necessary to make the drawings on some transparent medium. After various trials a tracing paper called "Vellum" was adopted, being very transparent, fairly easy to work on, and of fair erasing quality. Except for work that required very accurate lay-outs, all drawings were made directly on this paper with a soft pencil, about 2H or 3H. Excellent blueprints could then be made direct from the original drawings without the necessity of inking in. This change speeded up the work of the department considerably, but did not give the kind of men wanted, so an advertisement was published for toolmakers with a knowledge of drafting for a tool-designing department. For this the writer was roundly criticized by one of the men, who said that it looked as though toolmakers rather than draftsmen were wanted. This was the case, as he discovered when he received his next pay check. That the plan of using toolmaker tool designers was satisfactory was proved by the number the superintendent transferred to more responsible positions in the organization, and by the writer's advancement two months later, when the tooling proposition was well in hand, to the position of assistant superintendent.

Changes Made in a Canadian Plant

Later, an attractive offer from a Canadian firm engaged in the same line took the writer to Canada, ostensibly to become tool-room foreman but actually to improve upon methods. Conditions there were much the same as they had been with the firm he had just left. The drafting department consisted of two men. One, who had the title of chief draftsman and received $25 a week, was as fast a worker as the writer has met, but he had absolutely no knowledge of shop practice and could only work to sketches or at the direction of someone else. The other man was employed as a tracer. Ideas had been furnished by the various department heads and by the superintendent. The former had little knowledge of time-fuse manufacture, while the latter, though a fine mechanic, had his attention so taken up with his executive duties that it was impossible for him to give the matter the attention that was needed.

The principal trouble was with the large parts of the time fuse, namely, the body, rings, cap and base plug. The brass forgings were extremely hard and gritty, probably having been made of sweepings and other miscellaneous scrap metal. In fact they were so bad that the New Britain chucking machines used on the roughing operations were not strong enough and consequently were frequently in need of repairs. Also, the tool-heads, each of which required a half dozen tools, were designed to take square tool bits through broached holes, which are almost impossible to machine accurately. As a result, no two heads were standard in that respect, so that the tools had to be ground according to the head for which they were intended. Later heads were made to take a form tool that could be ground on the face and always retain its shape, and care was exercised to make them interchangeable.

For the finishing operations on the body and cap, the firm had designed semi-automatic machines, which were built in shops that were more familiar with agricultural implements, or wheel-barrows than with the exacting requirements of high-grade tool work. All fits on the machines had been "cataleptic." The spindles (2½ to 3 inches in diameter) were made from a poor grade of wrought iron, were full of seams, and were run direct in cast-iron bearings; but oftentimes the oil-holes had no connecting oil-grooves, although the machines were designed to run at speeds of about 1500 revolutions per minute. These machines, over thirty all told, were designed primarily to do the work ordinarily done on plain turret screw machines. How well they served the purpose may be gathered from the writer's experience with them.

The machines that were intended to form the outside of the cap had two slides working up and down in a vertical plane; one of these carried the roughing tool and the other the finishing tool. These slides received their motion from cams, which had to have a rather long dwell, as they were driven direct from the work-spindle, which had to be stopped with a hand-brake. This brake consisted of a block of wood that was wedged in between the belt and the frame of the machine after the overhead clutch was thrown out. The caps were screwed onto an arbor that was operated by means of an eccentric stud and a socket wrench. As the production per machine never exceeded 500 caps per day, ten machines had been built for a daily production of 5000 caps. As a matter of fact, it took all ten machines to get a production of from 1000 to 1500 caps per day, for there was a continuous procession of these machines to and from the tool-room, in the care of toolmakers, machinists, and belt men.

As the oil-holes were uncovered, they served as excellent catch-alls in which were collected the flying particles of brass thrown off by the tools when the machines were in use. The result was the wearing away, in a twenty-four-hour run, of as much as one-sixteenth inch of metal from the top of the bearings, where the pressure of both the cut and the pull of a heavy four-inch belt came. In addition, the cap forgings were not uniform in size, so the machines frequently stalled, jamming the cutters into the work and often breaking the threaded arbor on which the work was held.

The writer fitted all these machines with hollow spindles of pack-hardened and ground machinery steel that were fitted with draw-back arbors operated by a hand-lever at the left, of similar construction to that found on the usual run of hand screw machines. The automatic slides were replaced by a heavy cross-slide operated by a rack and pinion and a hand-lever; this also was like a screw machine cross-slide except that it was about seven inches wide while in screw machines of approximately the same size the slide is about four inches wide. A roughing and a finishing tool were mounted on this cross-slide, one in front and the other at the back. Felt wipers placed in grooves cut at the bottom of the bearings and sight-feed oil-cups insured a good supply of oil to the bearings. The production immediately rose from a possible 500 to an actual 2000 rings per day per machine, and the procession of machines to the tool-room ceased.

Besides, there were seven of these cap shavers that could then be converted to other purposes. These were, therefore, fitted up the same as the machines just described, with the exception of the chucks and tools and were then used for turning the bevel and facing the rings. These operations had previously been done on No. 4 Stark bench lathes, fitted with simple expansion chucks and using the regular compound cross-slide, with a special tool-block fitted up to take two tools. This change, from a light and inadequately powered machine, to a high power and efficient one, raised the production from about 1500 to 4000 rings a day. In addition, it gave the nucleus of a bench-lathe equipment for the tool-room, something that was badly needed. As some grinding attachments, collets, countershafts with grinding counters attached, etc., that had been ordered long before were received at this time, the plant then had the necessary equipment for making the hundred and one kinds of small gages that had previously been made outside, as well as bushings for drill jigs, etc. The lack of this equipment had handicapped the plant, for large machines that were badly needed for other purposes were frequently tied up with this work.

These are only a few of the many instances where changes were made. Machinery, jigs, fixtures, and tools were discarded and in most instances replaced with better that not only cost less money, but increased production greatly. For instance, a special milling machine that weighed about a ton and had cost, duty and all, probably a couple of thousand dollars, failed to produce sufficiently accurate work, was always getting out of repair, and never produced more than 1200, good, bad, and indifferent pieces, so it was replaced by a milling machine that was built in the tool-room, weighed less than seventy-five pounds, and cost less than $200, but which had a capacity of 5000 pieces and could be depended on to produce uniformly good work.

Economies Effected by Rearrangement of Plant

Recently the writer was asked by a man for whom he once worked, and who is mechanical superintendent of one of the plants of a very large concern, to join his organization, if only for a month, and help push through the tooling up of a new job. The work was along the same lines as that they had just completed, but there were some changes in size and construction; the plant employs about 6000 men, most of whom are machine operators. As it was possible for the writer to get away from the work he was then on, arrangements were made whereby he was able to join the organization for two months.

This plant had just finished a large contract on a certain class and size of work, and the men were, or should have been, familiar with all the best methods for producing this particular line. Yet it was possible for the writer after going through the plant under the guidance of the chief draftsman one Saturday afternoon, to lay out between then and the following Monday, changes that saved in labor costs alone upward of $5000, and this with very little expense. This alone would pay the writer's salary for the period he was there several times over, even though he accomplished no more. A few days later, while strolling through the plant, his attention was called to a group of men who were coiling lead cable on reels as it came from the extrusion presses. There were thirty-two reels in the installation, sixteen being wound at one time while the others were spare reels mounted alongside the live reels and were used as soon as the others were filled. Sixteen men were required, one man to a reel, so the writer immediately tried to devise some way to do the work by machinery and do away with the men. At once the bobbin winder on the common household sewing machine came to his mind, so it only remained to put the idea in practical shape and to keep the cost low enough to make it a paying proposition. He was told that to be on the safe side he should figure the job as if it were only to last three months. On that basis, a winding mechanism was designed the estimated cost of which did not exceed $2000. At this rate and estimating the time of the fourteen men that it will replace, two being kept to change the cable from the full reels to the empty and to look after the oling, etc., of the machinery, the saving would amount to about $3000. Should the work last longer than the three months, as it undoubtedly will, the saving would be greater in proportion.

In practically every instance, the loss occasioned by these mistakes would have been avoided had an experienced tool designer been put on the job in the first place and been allowed to devote all his attention to this work. Some may say that it is hard to get such men, but to statements of this kind there is only one answer. "Pay the price and the men can be had." Their salary, no matter how large it may seem, will be very small in proportion to the price that will be paid for such mistakes as those that have been described and which seem to be very common in munition work. These mistakes are also due to the tendency of executives to turn their hands to tool design rather than place the matter entirely in the hands of specialists, and make them entirely responsible for the results.

Lessons Taught by Experiences of Munitions Manufacturers

Summing up the results of his experience, it would seem to the writer that there is an unlimited field for the mechanic draftsman, and toolmaker tool designer to replace the technical mechanical draftsman. The former, at least the kind the writer has in mind, has put in the greater part of his working life at the actual making and designing of tools in the shop where they are to be used, and more often than not he has had to set them up and give them a thorough trial before they were turned over to the manufacturing department. He has learned from experience about what any given piece of metal will stand before it will break, and his judgment is not based on the working out of elaborate formulas of strength of materials, but is quite frequently the result of failures on the part of the technical draftsman to use a high enough factor of safety when designing the part. In other words, the best part of his knowledge has frequently been gained through the mistakes of others. In addition, he has a knowledge of cutting tools and their action and has had the opportunity of sharpening them in different ways and of noticing how they worked under different conditions. He has also run them to the breaking point in the effort to find out their limitations and the limitations of the machines in which they were being used. Speeds, feeds, and many other things for which there are no formulas have become matters of instinct, to be used when and where they are needed without hesitation. Besides he has been handling the work of other draftsmen in the form of blueprints, etc., from the time he entered the shop as an apprentice; he has been in a position to criticize their work, to discriminate between the good and the bad, and if he has had the initiative he should have to be a success, there

have probably been many times when he has been allowed to work out his own ideas as opposed to the ideas sent out from the drafting department. He cannot have failed to notice the innumerable useless dimensions put on the average drawing, and having noticed, and being in a position to know very nearly what his brother mechanic will require, his drawings will not have this fault. Knowing also the methods that will be used in machining every detail of the parts which he designs, each part is machined mentally as it takes form under his pencil, and so, as he puts himself in the place of the man at the machine, he is very careful to see that so far as possible difficult machining operations are eliminated from his designs. Also, as the work on the board progresses he is mentally assembling the parts one by one in the rotation the man in the shop will afterward use, and in that way he avoids the expensive mistakes, which are all too common, of forgetting to allow proper clearance. For instance, not long ago an expensive and elaborate jig was given to the writer to assemble, the rough work on the parts having already been done by various machine operators who had not seen the assembly drawing or were not in position to criticize it. This jig had been designed by a young man fresh from school who was not accustomed to work of this kind, and while it looked all right on paper, at first glance, a shouldered spindle could not be placed in its bearing because of its length, another bearing in front of it interfering; this bearing was also too small for the spindle to pass through and into its own bearing. As a result, the parts had to be scrapped and a new design made. Had this jig been assembled, even mentally, as it was being drawn, this mistake would not have occurred. And so, henceforth, give the writer men who have had their hard knocks in the shop first; even though they cannot write the name of some famous school on their application blank, if they have been students of the "College of the Midnight Lamp" they will not go very far wrong.

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PIECEWORK PRICES

A workman is paid for what he does, no matter whether he is working by the day, week or month. Actual production, in the last analysis, is what determines his rate of pay. Hence, the piecework system under which a workman is paid directly in proportion to effort is undoubtedly the most equitable and satisfactory system of compensation, when honestly administered, that has ever been devised. The difficulty with the piecework system is the lack of mutual honesty. Secretary William C. Redfield of the Department of Commerce and Labor, at an editorial conference meeting in New York in October, quoted from an address of the Right Hon. Christopher Addison to the British Parliament on the work of the administrator of munitions in Great Britain, as follows:

> Nothing in the relations between labor and capital gives rise to more difficulty and distrust than two customs which are dependent upon each other. The first is the cutting of rates of pay on piecework, so as to limit the increase of earnings when improved methods of manufacture leading to a greater output are introduced. It is not the practice of the best employers, but it is adopted by many. This practice, or the fear of it, has inevitably led to the second and retaliatory practice of the reduction of output. The influence of these two practices in our industrial life is poisonous. We must establish a system whereby both classes have a direct interest in the introduction of improved methods. Without it our progress will inevitably be accompanied by endless disputes. The accounting side of the ministry has abundantly proved that modern methods of production are not only well able to afford good wage rates, but are benefited by so doing.

* * *

On account of the present high price of coal in the Scandinavian countries, a wrecking company has started work in an effort to recover a cargo of 1200 tons of coal that has lain at the bottom of the Great Belt, a mile north of Nyborg, Denmark, for thirty-four years. The cargo was that of the steamer *Dorka*, which sank in 1883. It is believed that nearly a thousand tons can be recovered. Samples recovered show the coal to be undamaged by its long immersion.

COMBINED TWISTING AND BENDING MOMENTS[1]

BY VICTOR M. SUMMA[2]

It would seem that an article on the subject of combined twisting and bending moments should not require publication, as the subject is dealt with in all text-books and handbooks on the strength of materials and machine design. However, there seems to be considerable confusion, not only among mechanical men generally but also among well-informed engineers, as to the proper application of the formulas that are available in the engineering handbooks, the two most well known being the Rankine formula and the Guest formula. Hence, an elementary article on the subject, stating the conditions in simple language, will probably be of value to many. The writer would say at the start that in his opinion there is absolutely nothing the matter with either of the two formulas

$$T_e = M + \sqrt{M^2 + T^2}$$

$$M_e = \tfrac{1}{2}M + \tfrac{1}{2}\sqrt{M^2 + T^2}$$

which are generally known as the Rankine formulas, and in which

T_e = equivalent twisting moment due to combined bending and twisting stresses;

M_e = equivalent bending moment due to combined bending and twisting stresses;

M = bending moment due to bending stresses alone;

T = twisting moment due to twisting stresses alone.

The two formulas above are based upon two others, namely,

$$P_1 = \tfrac{1}{2}(S + \sqrt{S^2 + 4S_s^2})$$

$$P_2 = \tfrac{1}{2}\sqrt{S^2 + 4S_s^2}$$

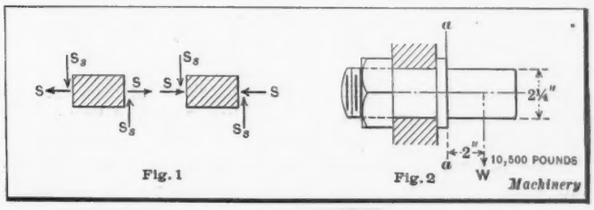
in which S = unit stress in tension or compression;

S_s = unit stress in shear;

P_1 = greatest unit stress in tension or compression produced by the simultaneous stresses S and S_s;

P_2 = greatest unit stress in shear produced by the simultaneous stresses S and S_s.

In order to show the application of these formulas, a few examples will be worked out. It should be noted at this point



Figs. 1 and 2. Notation used in Formulas and Examples

that in the derivation of these equations no account is taken of the shape of the cross-section of the strained body and that the formulas are, therefore, of general application. The only assumption made is that an "indefinitely small particle of material" is subjected to stresses, as indicated in Fig. 1; that is, that the tension or compression stress and the shear stress act normally to each other at that point. The examples that follow will make this clear.

Example 1—It is required to find the maximum resultant unit stress in a ¾-inch square rod, subjected to a longitudinal pull of 7500 pounds and at the same time to a transverse shear of 5000 pounds.

It is first necessary to find the values of the unit stresses S and S_s. These are obtained by dividing the given forces by the area of the cross-section of the rod. Thus,

$$S = \frac{7500}{0.75^2} = 13{,}330 \text{ pounds, and } S_s = \frac{5000}{0.75^2} = 8880 \text{ pounds}$$

Then, by substitution, we have as maximum stresses:

$P_1 = \tfrac{1}{2}(13{,}330 + \sqrt{13{,}330^2 + 4 \times 8880^2}) = 17{,}770$ pounds per square inch in tension, and

$P_2 = \tfrac{1}{2}\sqrt{13{,}330^2 + 4 \times 8880^2} = 11{,}000$ pounds per square inch in shear.

Example 2—A pin 2¼ inches in diameter supports a load of 10,500 pounds as shown in Fig. 2. Find the greatest stresses.

[1] See also MACHINERY, August, 1914, "Compound Stresses," and March, 1916, "Formulas for Combined Bending and Torsional Stresses."

[2] Examining Engineer, American Brake Co., St. Louis, Mo.

These stresses obviously occur at cross-section a–a, where there is a combination of shear and bending.

In this case, the unit values of S and S_s are

$$S = \frac{M}{Z}, \text{ and } S_s = \frac{W}{A}$$

in which M is the bending moment of load W about a–a; Z, the rectangular modulus of resistance of cross-section a–a; and A, its area; or

$$S = \frac{10{,}500 \times 2 \times 10.2}{2.25^3} = 18{,}800 \text{ pounds per square inch, and}$$

$$S_s = \frac{10{,}500}{3.14 \times 1.125^2} = 2640 \text{ pounds per square inch}$$

Then their maximum combined effects are:

$P_1 = \frac{1}{2}\,(18{,}800 + \sqrt{18{,}800^2 + 4 \times 2640^2}) = 19{,}160$ pounds per square inch in tension or compression, and

$P_2 = \frac{1}{2}\sqrt{18{,}800^2 + 4 \times 2640^2} = 9760$ pounds per square inch in shear.

Example 3—A square shaft is subjected to a torsional moment of 80,000 inch-pounds and at the same time to a bending moment of 100,000 inch-pounds. Find the size of the cross-section required to withstand the combined moments safely, taking the working unit-stresses of the material at 12,000 pounds in tension and 9600 pounds in shear.

Let a be the side of the required square. Then the unit stresses are:

$$S = \frac{100{,}000}{a^3 \div 6} \text{ and } S_s = \frac{80{,}000}{2/9\,a^3}$$

where $a^3 \div 6$ and $2/9a^3$ are the rectangular and polar section moduli for square sections. Substituting, we have:

$$12{,}000 = \tfrac{1}{2}\left(\frac{100{,}000 \times 6}{a^3} + \sqrt{\frac{100{,}000^2 \times 36}{a^6} + \frac{4 \times 80{,}000^2 \times 81}{4a^6}}\right)$$

from which

$$a^3 = 64, \text{ and } a = 4 \text{ inches}$$

Similarly, as we were requested not to exceed 9600 pounds in shear, we must ascertain the value a would have in shear. So, by using the second formula, we have also:

$$9600 = \tfrac{1}{2}\sqrt{\frac{100{,}000^2 \times 36}{a^6} + \frac{4 \times 80{,}000^2 \times 81}{4a^6}}$$

$a^3 = 48.8$, and $a = 3.66$ inches, thus showing that the side of the required square must be 4 inches, as found by the first equation.

These examples will suffice to give a fair idea of the many and varied uses to which the two fundamental equations

$$P_1 = \tfrac{1}{2}\,(S + \sqrt{S^2 + 4S_s^2}) \text{ and } P_2 = \tfrac{1}{2}\sqrt{S^2 + 4S_s^2}$$

can be put, and of their great value in structural and machine designing. There are few cases in practice where some member at least is not subjected to a combination of simultaneous strains, such as pull and twist, bending and cross-shear, or a wrenching of some sort; and the steel designer could learn nothing more useful than these formulas.

Now we will return to Rankine's well-known expressions

$$T_e = M + \sqrt{M^2 + T^2}$$

and

$$M_e = \tfrac{1}{2}M + \tfrac{1}{2}\sqrt{M^2 + T^2}$$

As already stated, there is, in the writer's opinion, nothing the matter with them except that they have been widely misunderstood and, of course, misapplied.

Take the case of a round shaft subjected to a bending moment M and at the same time to a twisting moment T. Then, remembering that for circular cross-sections the modulus of section for torsion is double the modulus of section for bending, that is, that $Z_p = 2Z$, we have as unit stresses:

$$S = \frac{M}{Z} \text{ and } S_s = \frac{T}{2Z}$$

By substituting these values in the formula for P_1 given above, we have:

$$P_1 = \tfrac{1}{2}\left(\frac{M}{Z} + \sqrt{\left(\frac{M}{Z}\right)^2 + 4\left(\frac{T}{2Z}\right)^2}\right)$$

$$= \tfrac{1}{2}\left(\frac{M}{Z} + \frac{1}{Z}\sqrt{M^2 + T^2}\right)$$

$$= \frac{1}{2Z}\,(M + \sqrt{M^2 + T^2})$$

$$P_1 = \frac{M + \sqrt{M^2 + T^2}}{2Z}, \text{ or } P_1 = \frac{\tfrac{1}{2}M + \tfrac{1}{2}\sqrt{M^2 + T^2}}{Z}$$

The numerator $M + \sqrt{M^2 + T^2}$ of the first fraction, being divided by $2Z$ (or Z_p), that is, by the polar section modulus, is called the "equivalent torsional moment," abbreviated T_e; while the numerator of the second fraction, being divided by the section modulus for bending, is termed the "equivalent bending moment," abbreviated M_e. Hence, the two important results:

$$T_e = M + \sqrt{M^2 + T^2} \text{ and } M_e = \tfrac{1}{2}M + \tfrac{1}{2}\sqrt{M^2 + T^2}$$

These expressions refer only and always to P_1, that is, to the tensile or compressive stress, and not to P_2, the shear stress, as is generally thought when the equivalent torsional moment is used. It is also clear, now, why it would be an error to apply them to non-circular bars, as is too often done, to the discredit of Rankine and his formulas. The fact to keep in mind is that the metamorphosis of $P_1 = \frac{1}{2}(S + \sqrt{S^2 + 4S_s^2})$ was made possible because the Z_p and the Z for circular cross-sections happen to be one double the other, as the following values clearly indicate:

$$Z_p = \frac{\pi d^3}{16}, \text{ and } Z = \frac{\pi d^3}{32}, \text{ for solid shafts;}$$

$$Z_p = \frac{\pi(D^4 - d^4)}{16D}, \text{ and } Z = \frac{\pi(D^4 - d^4)}{32D}, \text{ for hollow shafts.}$$

But the same thing cannot be said of other sections; and an inspection of the following values for square and rectangular shafts, as an instance,

$$Z_p = \frac{2a^3}{9},\ Z = \frac{a^3}{6};\ \text{and } Z_p = \frac{2}{9}\,ab^2,\ Z = \frac{ba^2}{6}$$

proves that Z_p is far from being double Z.

In a similar way, $P_2 = \frac{1}{2}\sqrt{S^2 + 4S_s^2}$ would become:

$$P_2 = \frac{\sqrt{M^2 + T^2}}{Z_p}, \text{ or } P_2 = \frac{\tfrac{1}{2}\sqrt{M^2 + T^2}}{Z}$$

and we could write down two more important results, *viz.*,

$$T_{es} = \sqrt{M^2 + T^2} \text{ and } M_{es} = \tfrac{1}{2}\sqrt{M^2 + T^2}$$

where T_{es} and M_{es} are, respectively, the equivalent torsional and the equivalent bending moments for shear, corresponding to T_e and M_e, the equivalent moments for tension or compression.

The second of these two expressions is known as the Guest formula, since Mr. Guest seems to have been one of the first to prove experimentally the correctness of an otherwise purely theoretical deduction. The dropping of the coefficient before the radical is due to the fact that he gives to P_2 (the safe working stress in shear) a value in tension which is assumed as twice that in shear. In other words,

$$P_2 Z = \tfrac{1}{2}\sqrt{M^2 + T^2}$$

can take the following specific forms:

$$6000Z = \tfrac{1}{2}\sqrt{M^2 + T^2}, \text{ or } 12{,}000Z = \sqrt{M^2 + T^2}, \text{ or}$$

$$SZ = \sqrt{M^2 + T^2}$$

S standing, of course, for the maximum allowable working stress in tension or compression.

The meaning of Guest's formula deduced above does not agree with that given by G. B. Upton, and published in MACHINERY, March, 1916. There seems to be a great deal of confusion as to the exact meaning of the symbols in this formula, and further discussion is invited. It has been generally understood, we believe, that Guest's formula is empirical, and probably the attempt at a mathematical deduction above accounts for the discrepancy. In Guest's original paper, published in the *Philosophical Magazine*, July, 1900, he does not specify whether S is to be understood as maximum working stress in tension or in shear; hence some have interpreted the formula one way and some another.—EDITOR

* * *

The Pennsylvania Railroad, on the lines east of Pittsburg and Erie, was employing, at the beginning of August this year, in the operating department alone, 2360 women in positions formerly filled by men. These included signalwomen, dispatchers, station cleaners, draftswomen, messengers, station agents, ticket sellers, pump attendants, block operators, machine hands, watch women and drawbridge tenders.

RUSTPROOFING IRON AND STEEL

ADVANTAGES AND LIMITATIONS OF PHOSPHATIC TREATMENT

BY JOSEPH W. WUNSCH[1]

THE object of this article is to show the principles of the phosphatic treatment of iron and steel as a preventive of rusting. There has been no intention to convey information that will enable the reader to engage in processing, cook-book fashion. The various patented processes have been merged and presented so as to be most easily understood by the engineer and machine builder. The basic principle of all processes lies in the deposition of a coat of insoluble ferrous phosphate on the iron or steel to be protected. The obstacles encountered have been in the control and regulation of the processing, particularly in obtaining a permanent deposition, and the developments during the past decade have been mainly improvements in that direction.

Iron, when placed in a solution of such acids as hydrochloric, sulphuric or nitric acid, is attacked and dissolved, precipitating ferrous salts. If a dilute phosphoric acid is used, a more or less adherent coat of insoluble ferrous phosphate is formed, which in the presence of an oxidizing agent becomes basic in character and black. If a piece of iron is placed in a hot basic solution of ferric chloride or ferric sulphate, a black basic salt is formed which adheres to the metal. When the iron is removed and placed in a hot solution of an alkali phosphate, such as disodium or trisodium phosphate, the adherent film becomes permanent.

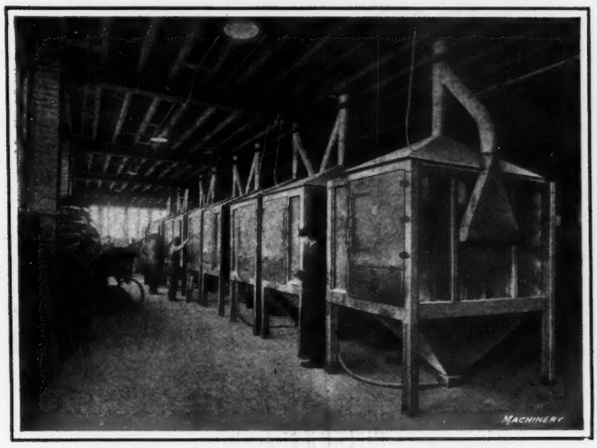


Fig. 1. Section of Sandblast Department of Parker Rust-proof Co., Detroit

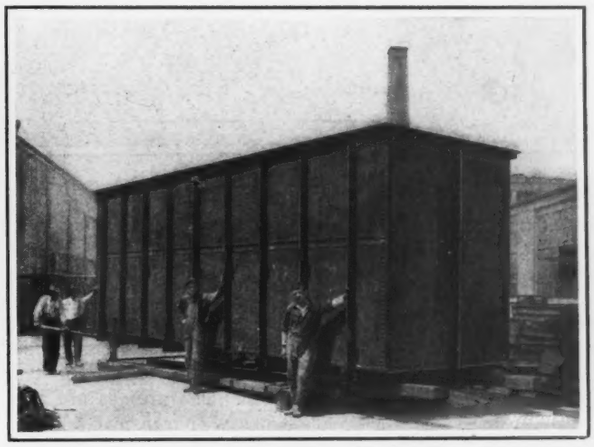


Fig. 2. Tank in which Two Ford Cars can be processed at One Time

The governing of these reactions is quite difficult and the various processes described here differ essentially only in the chemical or mechanical agencies introduced for the more efficient regulation and control of the processing. In the earliest application of the phosphatic process, the iron was treated with a solution of glacial phosphoric acid in water.

Iron Phosphate Process

Thomas Watts Coslett, an English chemist, was granted letters patent in 1907 for a process in which dilute phosphoric acid is employed, with iron in the form of iron filings or ferrous phosphate as the regulating agency. A solution that has been found to give satisfactory results in rustproofing iron and steel contains 1 ounce of iron, in the form of powder, 4 fluid ounces of concentrated phosphoric acid, and 160 fluid ounces of water.

In carrying out the process, a quantity of this solution is placed in an enameled iron bath and heated to the boiling point. The article to be treated, after being thoroughly cleaned, is then immersed and the solution evaporated until the desired coating of ferrous phosphate has been deposited. The articles are then withdrawn from the solution and, after being wiped and dried, may be oiled to set the tone of the deposit.

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Zinc Phosphate Process

In a later process, zinc is employed as the controlling agent. By this method the iron is subjected to the action of phosphoric acid in the presence of zinc, zinc oxide, or zinc phosphate. The solution obtained by the action of the phosphoric acid upon the zinc is preferably made in concentrated condition. The concentrated solution may afterward be separated from any sediment or excess of zinc, and then applied to the iron or steel articles in concentrated or dilute solutions. The concentrated solution has about the following proportions: zinc, 6 ounces; phosphoric acid, 1 pint; water, 1 pint. A suitable dilute solution contains one ounce of the concentrated solution to one gallon of water.

Under certain circumstances, it may be of advantage to treat the iron or steel with a solution containing not only zinc phosphate, but also iron phosphate. In such cases, the iron filings or ferrous phosphate is dissolved with the zinc, or zinc compound, in the phosphoric acid; or the solution of zinc phosphate may be added to the solution in which the deposit of phosphate of iron on the article is being effected. The effect of the zinc-phosphate solution on the surface of the iron or steel under treatment is similar to that of the phosphoric acid on metallic zinc, as a certain amount of zinc must be dissolved to form phosphate of zinc before any deposition is formed. The coating consists essentially of normal zinc phosphate mixed with small amounts of normal ferrous phosphate and free phosphoric acid. The latter can be reduced by thorough washing. The normal ferrous phosphate is formed by the interaction of the free phosphoric acid with the metal treated. Iron or steel coated with phosphate of iron may be subjected to the zinc solution.

The formation of the deposit on iron or steel may be accelerated by passing an electric current through the dilute solution, as when electroplating. Iron plates are connected with the positive pole of the battery or low-voltage dynamo and the article to be rustproofed is connected to the negative pole.

Manganese and Iron Phosphate Process

A permanent protective phosphate deposit on iron and steel may also be obtained by the use of a solution of manganese dioxide dissolved in phosphoric acid. A satisfactory deposit, which consists, substantially, of manganese and iron phosphates, may be obtained after an immersion of from thirty to ninety minutes in a solution prepared by dissolving manganese phosphate in phosphoric acid and diluting to an acidity of 0.1 per cent.

The manganese phosphate may be prepared by decomposing the sulphate with phosphate of sodium. The process is car-

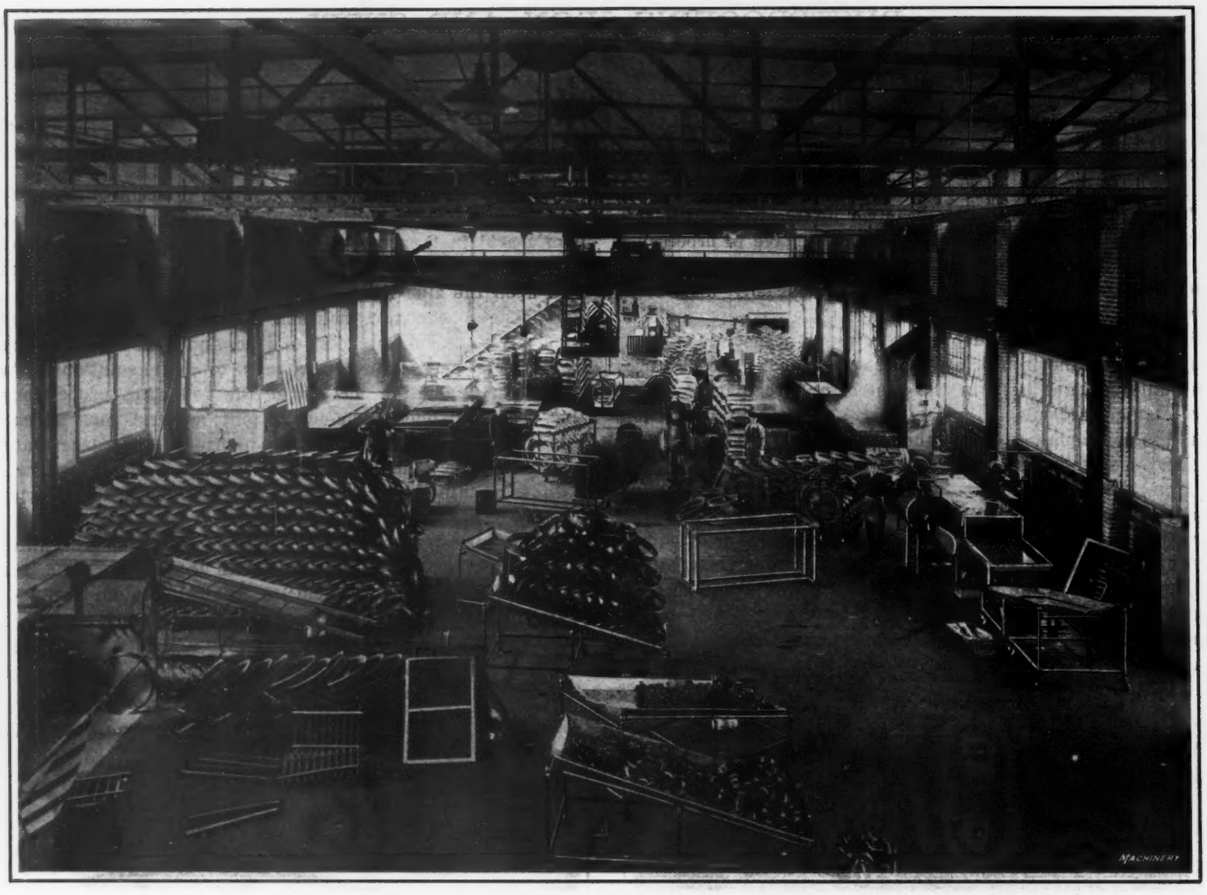


Fig. 3. Main Processing Plant of Parker Rust-proof Co.

ried out by heating the solution nearly to the boiling point and immersing the metal articles to be treated. A very small amount of the iron goes into solution and some hydrogen is set free, gradually diminishing to a slight reaction after about half an hour. The metal remains in the hot solution for from one to three hours, or until all action ceases, and the surface of the metal is changed to basic phosphates, which cannot be penetrated by the acids of the bath. The articles are then removed, dried and oiled. Fresh pieces of iron placed in the bath will be acted upon at once until the bath is exhausted. This process has a great advantage over that employing manganese dioxide, for the solution is clear and can be adjusted in strength at the beginning to suit the different classes of articles to be acted upon. The bath remains a solution of manganese phosphate until the introduction of iron or steel upsets the equilibrium of the solution by some of the iron being dissolved.

Alkali Earth Metals and Iron Phosphate Process

The violent reactions of free phosphoric acid with the iron in the processing solution may also be avoided by the use of an acid phosphate salt of the alkali earth metals (calcium, magnesium, etc.) in the presence of hydrated manganic oxide. As the radical PO_4 is in union with the alkali earth metal, calcium, for example, it will not readily form soluble iron phosphate, but forms the insoluble ferrous phosphate at the points of contact when iron is introduced. The soluble acid calcium phosphate, $2Ca\ H_4(PO_4)_2$ (monocalcium phosphate), is converted into the insoluble acid calcium phosphate $Ca_2H_2(PO_4)_2$ (dicalcium phosphate). If during the formation of the deposit of ferrous phosphate an oxidizing agent is present, some ferroso-ferric phosphates are formed and the surface of the iron becomes black. The reaction is probably as follows:

$$4CaH_4(PO_4)_2 + 8Fe + 2O_2 = 2Ca_2H_2(PO_4)_2 + Fe_3(PO_4)_2 \cdot Fe_2O_4 \cdot Fe_2(PO_4)_2 + 6H_2$$

The oxidizing agents used are hydrated manganic oxide, $Mn_2O_2H_2O$, and air, which is forced up through the solution in fine sprays. It is noteworthy that practically no free phosphoric acid is present in this solution and that the affected surface of the article of iron or steel, in the solution, has no tendency to separate from the body of the article. As the acid radical is in union with the calcium, it will not form the soluble iron acid phosphate, as in the case where free phosphoric acid is used.

Ferric Phosphate Process

In the ferric phosphate process, the iron is oxidized outside the bath. Ferric phosphate prepared by any well-known method is dissolved in phosphoric acid, forming a soluble acid ferric phosphate. One of the advantages of this method is that the strong solution of acid ferric phosphate can be shipped to factories ready for use by diluting with water, thereby producing an oxidizing bath of known acid ferric phosphate content; the bath is made of approximately the same acid strength as previously mentioned.

Preparation of Articles for Rustproofing Bath

Articles to be treated by the phosphatic process must be chemically clean to insure a perfect deposition of the protective coat of phosphates of iron. The articles are cleaned much the same as in electroplating, using the sandblast, acid pickling and alkali washes to remove coarse dirt, scale and grease, respectively. Sulphuric acid has generally been employed for the pickling bath.

Patents have recently been granted for the use of a strong phosphoric-acid pickling solution. It is claimed that the pickling cannot be properly performed by sulphuric acid for the reason that the removal of all traces of its basic salts is practically impossible, and as these basic sulphates are insoluble in the rustproofing bath, blotches result which rust almost immediately upon exposure to the air. This is also true when hydrochloric and nitric acids are used. It is well to remember that when phosphoric-acid pickling is employed and the acid is permitted to dry on the articles to be treated, or time is allowed for the action of the adherent acid phosphate solution, ferrous phosphates will be deposited upon the

articles to be treated, which, when once formed, will not dissolve in the rustproofing bath. But when the articles are taken from the hot, strong, phosphoric-acid pickling bath and plunged immediately into the rustproofing bath, before the solution can evaporate, no such insoluble salts will be formed; the acid clinging to the articles will be taken up by the rustproofing bath and there will be formed on the articles the desired black surface of basic phosphates of iron.

Finish of Rustproofed Articles

The natural finish from the process is a steel gray, which when oiled becomes a uniform soft matte black. The phosphatic process may be often employed advantageously in combination with any other finish that may be desirable. Articles that are to be painted are not oiled, and the metal is left just as it comes from the chemical bath. The surface of the phosphatic processed metal is exceptionally well adapted for enameling, since there is a fine microscopic etching that helps to bind the enamel. If for any reason the enamel should crack, the exposed surface of the processed article will not rust, and consequently no peeling off of the enamel will occur, as is the case with enamelware that is not rustproofed. In cases where two or more coats of enamel are given to articles, one coat over the phosphate rustproof deposit may give better results.

The electroplating of the non-ferrous metals on iron and steel articles may also advantageously be preceded by phosphatic treatment, resulting in a more durable protective deposit and not seldom in a reduction in cost. In electroplating with nickel, the article is first finished, then greased, buffed, dipped in a hot potash solution, brushed with pumice, dipped in cold water, copper-plated, buffed, dipped in a potash solution and in hot water, brushed with pumice, dipped in cold water, and then nickel-plated. By employing the phosphatic process previous to the nickel-plating, the operations may be reduced to finishing the article, immersion in the phosphoric-acid solution, and immediately nickel-plating.[1]

Advantages and Limitations of Process

The field for an effective and economical rustproofing process is really limitless as long as iron and steel will rust. The predominant advantage of the process is its effect of increasing the longevity of iron and steel, because, when they are thoroughly processed, such metals are positively immune from corrosion due to atmospheric attack. Government statistics show that 23 per cent of all the iron and steel output in a year is "junked" because of rust. All forms of iron and steel articles can be processed, from dental needles to structural steel beams. The rustproofed article has its selling power increased to an extent that it would be difficult to estimate. Ranges, radiators, hardware, ornamental ironwork, iron fences, steel furniture, in fact, all iron and steel articles can be made commercially 100 per cent more valuable if rustproofed.

Another economical feature of rustproofing, particularly in the machine-building industry, is the substitution of processed iron and steel for articles heretofore made of copper, brass and aluminum. The substitution of rustproofed steel for an expensive alloy for automobile carburetors resulted in the saving of from sixty cents to over a dollar on every carburetor.

While the phosphatic processed article is absolutely immune from corrosion when exposed to severe atmospheric corrosive agencies, it will not withstand actual exposure to hydrochloric, muriatic, acetic, sulphuric or similar acids. Neither is it protected against corrosion when subjected to the constant attack of chemical fumes, although it will resist intermittent attacks well enough. Sterilizing solutions have no effect on processed iron and steel.

The mechanical equipment of a processing plant consists essentially of sandblasting apparatus, pickling tanks, tumbling barrels, and special tanks for the phosphatic processing. The latter are double steel tanks equipped with steam coils to cause a constant and uniform agitation of the solution. The accompanying illustrations are from a well equipped plant, in Detroit, that covers an area of four acres, and has a processing capacity of 200 tons of metal a day.

[1] For the rustproofing of iron and steel by processes of zinc-deposition, see "Protective Electroplating," in MACHINERY for June, 1917.

ANNUAL MEETING OF A. S. M. E.

The annual meeting of the American Society of Mechanical Engineers will be held in New York City, December 4 to 7, inclusive, the Engineering Societies Building being the headquarters. On Tuesday, December 4, honorary membership will be conferred upon Major-General George W. Goethals. On Wednesday morning, following the regular business meeting, there will be what is known as the "keynote session" of the meeting, dealing with "the service of the engineer to the public in times of crises," opened by the presidential address of Dr. Ira N. Hollis on "Universal Public Service in Peace and War." The technical papers to be presented follow:

"Preventable Waste of Coal in the United States," by David Moffat Myers.

"The Cooling of Water for Power Plant Purposes," by C. C. Thomas.

"Bagasse as a Source of Fuel," by E. C. Freeland.

"The Steam Motor in the Automotive Field," by E. T. Adams.

"The Transfer of Heat between a Flowing Gas and a Containing Flue," by Lawford H. Fry.

"A Study of Surface Resistance with Glass as the Transmission Medium," by H. R. Hammond and C. W. Holmberg.

"Cooling and Drying Air and the Removing of Infinitesimal Dust Therefrom," by W. J. Baldwin.

"Recent Developments in Balancing Apparatus," by N. W. Akimoff.

"Plotting Blower-test Curves," by A. H. Anderson.

"Cross-current Predeterminations from Crank-effort Diagrams," by Louis Illmer.

"An Account of the Engineering Work of E. D. Leavitt," by F. W. Dean.

"Expenses and Costs," by H. L. Gantt.

"By-product Coke and Coking Operations," by C. J. Ramsburg and F. W. Sperr, Jr.

"The Submarine," by C. H. Bedell.

"Combined Stresses," by A. L. Jenkins.

"The Trumble Refining Process," by N. W. Thompson.

"The Logic of Inspection," by A. L. DeLeeuw.

"The Relation of Inspection to Product," by F. A. Waldron.

"General Principles of Government Inspection and Relations between Inspectors and Manufacturers," by Col. B. W. Dunn.

"Labor-turnover Records and the Labor Problem," by Richard B. Gregg.

"Accident Prevention in the Textile Industry," by David S. Beyer.

"The Moisture Content of Textiles and Some of Its Effects," by William D. Hartshorne.

"The Engineer, the Cripple and the New Education," by Major Frank B. Gilbreth.

In addition to the papers read, there will be an industrial safety session on Wednesday afternoon, when several codes will be presented for discussion by the sub-committee on protection of industrial workers, among them the codes of safety standards for elevators and wood-working machinery.

The machine shop session will take place on Thursday afternoon, when there will be a topical discussion on the subject of inspection. On Friday morning there will be a management session, including a topical discussion on the employment of women in the skilled industries, with particular reference to war conditions; and also a power-test hearing, preliminary to a proposed revision of the power-test code of the society which comprises rules for conducting tests on prime movers of different types and auxiliary apparatus.

There will be a reception to the president and president-elect on Tuesday evening, a smoker and acquaintance meeting for members on Wednesday evening, and a lecture by Dr. John A. Brashear on "The Beautiful in Commonplace Things" on Thursday evening.

* * *

The first locomotive for American war-service railroads in France was completed by the Baldwin Locomotive Co. in twenty working days, and thirty engines of this type are now being turned out each day. This is in spite of the fact that the superheater boiler is used and must be constructed especially for this engine. The locomotive weighs about 166,400 pounds, and with the tender, about 275,000 pounds. Like all the equipment, it is painted battleship gray and bears the letters "U. S. A."

PERIPHERY OF THE ELLIPSE

BY J. J. CLARK [1]

Many formulas have been printed concerning the periphery of the ellipse, all of which are practically worthless when the ratio of the axes exceeds 8 or 9 to 1. The only exact expression for the periphery is by means of formulas that contain an infinite series, and no simple expression for the sum of these series has yet been derived. For about twenty-five years, the writer has been seeking a formula that would give reasonably accurate results for all ellipses, but without success. Several years ago he was desirous of checking the accuracy of an approximate construction of an ellipse by circular arcs by comparing the peripheries of the approximate ellipses with the corresponding true ellipses, but could find no formula that would apply to flat ellipses. However, a table was found in a well-known mechanical engineer's reference book that looked as though it would answer the purpose; but, unfortunately, the table was so full of errors that it could not be used. Later, the writer recalculated the table and found that of ninety-nine printed values only twenty-five were correct. The errors were evidently caused by not using a sufficient number of terms of the series.

In order better to understand the nature of the difficulty, let:

p = periphery;
a = semi-major axis;
b = semi-minor axis;
D = long diameter $= 2a$;
d = short diameter $= 2b$;

n = ratio of difference and sum of axes $= \dfrac{D-d}{D+d} = \dfrac{a-b}{a+b}$;

r = ratio of axes $= \dfrac{D}{d} = \dfrac{a}{b}$;

k = a constant.

Then:
$$p = \pi(a+b)k = \frac{\pi}{2}(D+d)k \qquad (1)$$

$$k = 1 + \left(\frac{1}{2}\right)^2 n^2 + \left(\frac{1}{2\times 4}\right)^2 n^4 + \left(\frac{1\times 3}{2\times 4\times 6}\right)^2 n^6 + \left(\frac{1\times 3\times 5}{2\times 4\times 6\times 8}\right)^2 n^8 + \text{etc.} \qquad (2)$$

Before discussing this series, it will be well to establish the relation between r and n, which is easily done; thus:

$$\frac{a-b}{a+b} = \frac{\dfrac{a}{b}-1}{\dfrac{a}{b}+1} = n = \frac{r-1}{r+1} \qquad (3)$$

From Equation (3):

$$r = \frac{1+n}{1-n} \qquad (4)$$

The limits of r are 1 and ∞, and the limits of n are 0 and 1; in other words, as n increases from 0 to 1, r increases from 1 to ∞. Thus, from Equation (3), for $r = 1$, $n = 0$, and from Equation (4), for $n = 1$, $r = \infty$. Moreover, comparatively small values of r give values of n that approach 1; and the nearer n is to 1, the greater must be the number of terms used in Equation (2) to obtain an accurate value of k. For example, for $n = 0.90$, $r = 19$, that is, the ratio of the axes is 19 to 1; and to obtain k correct to five significant figures, it will be necessary to use about twenty terms of the series. When the writer calculated the table above referred to, he extended the series (the law of which is evident) until the last term used gave a value less than 0.000000005, the result being to obtain the value of k to eight decimal places, with a possible error of one unit in the last place, but guaranteeing the correctness of the figure in the seventh place. For $n = 0.98$, it was necessary to use eighty-four terms of the series. But when $n = 0.98$, $r = 99$; hence when n increases from 0.98 to 1, r must increase from 99 to ∞. In fact, if n exceeds, say, 0.70 (for which $r = 5\,2/3$), it becomes increasingly difficult to obtain an accurate value for k.

[1] Address: 919 Sunset St., Scranton, Pa.

When $r = 1$, the axes are equal, and the ellipse becomes a circle; n is then 0, and by Formula (2), $k = 1$. When $r = \infty$, $b = 0$, and the ellipse becomes a right line, the periphery being equal to twice the major axis, or $4a$. Substituting in Formula (1), $k = \dfrac{4}{\pi} = 1.2732395+$. Therefore, the limits of k are: for $n = 0$, $k = 1$; and for $n = 1$, $k = 1.2732395+$. A little consideration of the limits of r, n, and k will make it evident why it is so difficult to obtain a formula that will work well for all values of r. The best formula that the writer has been able to find is one that was published about twenty years ago by Carl G. Barth, which is as follows:

$$k = \frac{64 - 3n^4}{64 - 16n^2} \qquad (5)$$

This formula is evidently an approximate summation of the series in Formula (2), since when the numerator is divided by the denominator,

$$k = 1 + \frac{1}{4}n^2 + \frac{1}{64}n^4 + \frac{1}{256}n^6 + \frac{1}{1024}n^8 + \text{etc.} \qquad (6)$$

The series in Formula (2) becomes, when reduced,

$$k = 1 + \frac{1}{4}n^2 + \frac{1}{64}n^4 + \frac{1}{256}n^6 + \frac{1}{656.36}n^8 + \text{etc.} \qquad (7)$$

The first four terms of Formulas (6) and (7) agree; but, beginning with the fifth term, this agreement ceases, and the two formulas drift apart rapidly. It recently occurred to the writer that a formula might be obtained based on the values calculated for the table, and by means of these values the following formula was derived:

$$k = 1 + 0.002011n + 0.228989n^2 + 0.075834n^3 - 0.09974n^4 + 0.066146n^5 \qquad (8)$$

This gives very good results for all values of n, as will be seen by comparison with the tabular values in the following table:

n	Formula k	Table k	Error
0	1	1	0
0.1	1.00256	1.00250	+ 0.00006
0.2	1.01003	1.01003	0
0.3	1.02261	1.02263	— 0.00002
0.4	1.04042	1.04042	0
0.6	1.09224	1.09224	0
0.5	1.06357	1.06354	+ 0.00003
0.7	1.12679	1.12683	— 0.00004
0.8	1.16781	1.16781	0
0.9	1.21619	1.21600	+ 0.00019
1.0	1.27324	1.27324	0

As might be expected, the greatest departure is between 0.9 and 1. Since Formula (5) will give five significant figures correct up to $n = 0.70$ (by Formula (5), $k = 1.126775+$ for $n = 0.70$), and since it is easier to apply than Formula (8), it occurred to the writer than it would be well to use Formula (5) for all values of n up to 0.70, and to derive a new formula for values of n between 0.70 and 1. The formula thus obtained is:

$$k = 0.147202 + 5.355178n - 13.197449n^2 + 16.892262n^3 - 10.613854n^4 + 2.689901n^5 \qquad (9)$$

This must not be used for values of n less than 0.70, for which $r = 5\,2/3$. The following table shows a comparison between values calculated by Formulas (8) and (9) and the table, for values of n between 0.90 and 1:

n	Formula (8) k	Table k	Error	Formula (9) k	Error
0.90	1.21619	1.216001	+ 0.00019	1.215999	— 0.000002
0.91	1.22148	1.221268	+ 0.00021	1.221264	— 0.000004
0.92	1.22686	1.226625	+ 0.00024	1.226629	+ 0.000004
0.93	1.23233	1.232074	+ 0.00026	1.232071	— 0.000003
0.94	1.23788	1.237620	+ 0.00026	1.237620	0
0.95	1.24353	1.243266	+ 0.00026	1.243270	+ 0.000004
0.96	1.24928	1.249016	+ 0.00026	1.249028	+ 0.000012
0.97	1.25512	1.254878	+ 0.00024	1.254897	+ 0.000019
0.98	1.26106	1.260859	+ 0.00020	1.260885	+ 0.000026
0.99	1.26710	1.266972	+ 0.00013	1.266997	+ 0.000025
1.00	1.27324	1.273240	0	1.273240	0

The right-hand error column shows that Formula (9) will give at least five significant figures correct for all values of n between 0.70 and 1, or, in other words, for all values of r between 5 2/3 and ∞; it is therefore sufficiently accurate for

all practical purposes. In the following table, which may be used instead of the formula, the values of k have been limited to five significant figures, because if they were given to a greater number of figures, it would be necessary to use second and even third differences for the larger values of n, when interpolating for intermediate values of k:

n	k	n	k	n	k	n	k
0	1	0.25	1.0157	0.50	1.0635	0.75	1.1465
0.01	1.0000	0.26	1.0170	0.51	1.0662	0.76	1.1506
0.02	1.0001	0.27	1.0183	0.52	1.0688	0.77	1.1548
0.03	1.0002	0.28	1.0197	0.53	1.0716	0.78	1.1591
0.04	1.0004	0.29	1.0211	0.54	1.0743	0.79	1.1634
0.05	1.0006	0.30	1.0226	0.55	1.0772	0.80	1.1678
0.06	1.0009	0.31	1.0242	0.56	1.0801	0.81	1.1723
0.07	1.0012	0.32	1.0258	0.57	1.0830	0.82	1.1768
0.08	1.0016	0.33	1.0274	0.58	1.0860	0.83	1.1815
0.09	1.0020	0.34	1.0291	0.59	1.0891	0.84	1.1862
0.10	1.0025	0.35	1.0309	0.60	1.0922	0.85	1.1909
0.11	1.0030	0.36	1.0327	0.61	1.0954	0.86	1.1958
0.12	1.0036	0.37	1.0345	0.62	1.0987	0.87	1.2007
0.13	1.0042	0.38	1.0364	0.63	1.1020	0.88	1.2057
0.14	1.0049	0.39	1.0384	0.64	1.1053	0.89	1.2108
0.15	1.0056	0.40	1.0404	0.65	1.1088	0.90	1.2160
0.16	1.0064	0.41	1.0425	0.66	1.1123	0.91	1.2213
0.17	1.0072	0.42	1.0446	0.67	1.1158	0.92	1.2266
0.18	1.0081	0.43	1.0468	0.68	1.1194	0.93	1.2321
0.19	1.0090	0.44	1.0490	0.69	1.1231	0.94	1.2376
0.20	1.0100	0.45	1.0513	0.70	1.1268	0.95	1.2433
0.21	1.0111	0.46	1.0536	0.71	1.1306	0.96	1.2490
0.22	1.0121	0.47	1.0560	0.72	1.1345	0.97	1.2549
0.23	1.0133	0.48	1.0585	0.73	1.1384	0.98	1.2609
0.24	1.0145	0.49	1.0610	0.74	1.1424	0.99	1.2670
0.25	1.0157	0.50	1.0635	0.75	1.1465	1.00	1.2732

Example—Find the periphery of an ellipse, the long and short diameters of which are 7 feet, 5 inches, and 9 inches, respectively. Since 7 feet, 5 inches = 89 inches, $n = \frac{89-9}{89+9} =$ 0.816326. From the table, obtain by interpolation $k = 1.1723 + (1.1768 - 1.1723) \times 0.6326 = 1.1751$. The value $0.6326 = \frac{0.816326 - 0.81}{0.82 - 0.81}$. Hence, by Formula (1),

$$p = \frac{3.1416}{2} (89 + 9) \times 1.1751 = 180.89 \text{ in.} = 15 \text{ ft., } 0.89 \text{ in.}$$

* * *

AIR-RIFLE PISTON DIES

BY W. B. GREENLEAF [1]

The accompanying illustrations show the piston for an air rifle and the dies for making it. In Fig. 1 the piston is shown, with the main spring in position and the leather washer riveted on the end, ready to go into the air barrel of the rifle. The projection on the lower side is engaged by a lever to compress the spring and also by the trigger. The metal used is 0.065-inch steel and the strip is wide and heavy. Considerable

[1]Address: Plymouth, Mich.

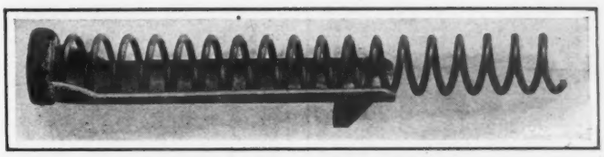


Fig. 1. Air-rifle Piston with Spring in Position

clearance must be left between the guides for variation in width, so that four pilots are necessary to obtain the required accuracy; three automatic trigger stops locate the strip from the first to the last stroke. In Fig. 2 are shown the stages in the development of the piston. *A* is the blank, *B* shows the second stage, and *C* is the completed piston.

As shown in Figs. 3 and 4, the blanking die is a double follow die, with the two blanks interlocking, so that the waste is reduced to a minimum. A forming station is set between the piercing and blanking stations to bend the web, which

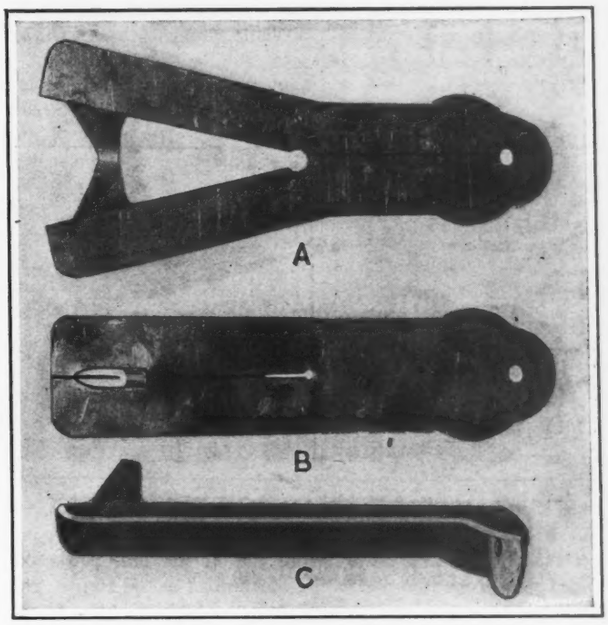


Fig. 2. Stages of Development of Piston

makes the lever and trigger hold. This forming punch is made in one piece with a large heavy pilot which enters the triangular hole and locates the strip at the second stage; there is also a pilot on each blanking punch.

The second-operation die, Fig. 5, bends the two legs of the blank together edgewise, and forces out and doubles up the web, which has already been started in the blanking die. The working parts of the punch and die are the same, each being

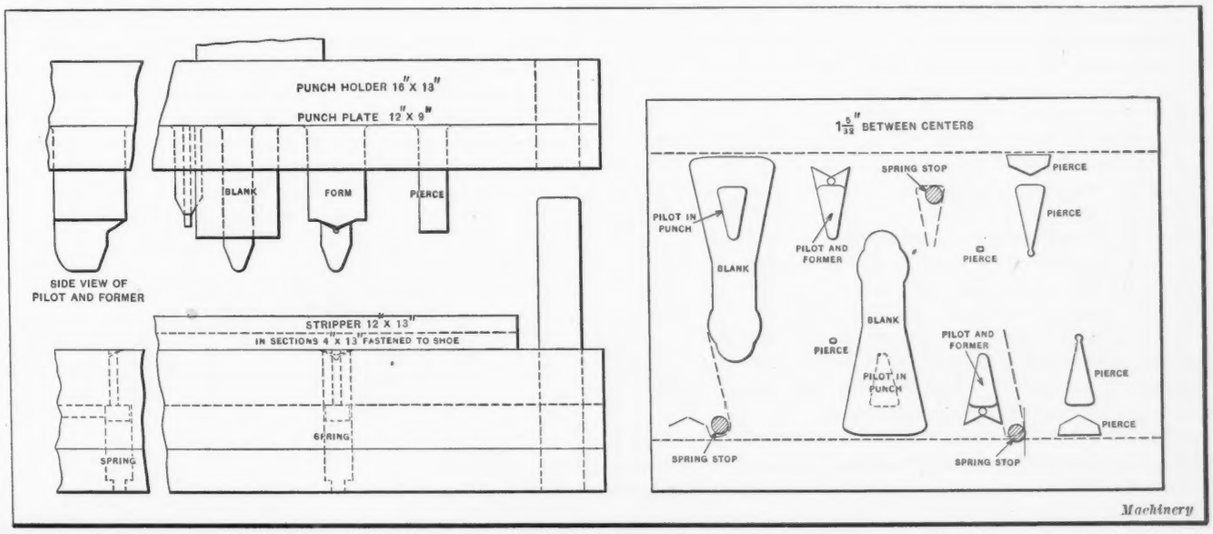
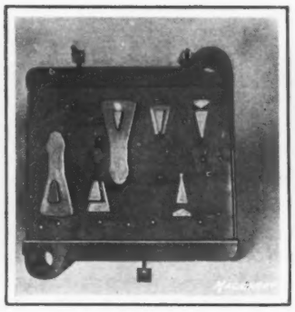


Fig. 3. Arrangement of Blanking Punch and Die



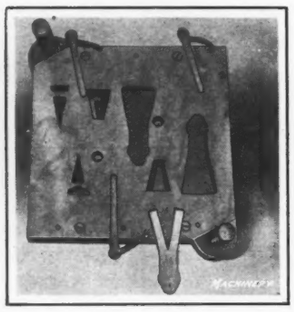


Fig. 4. Blanking Punch and Die for forming Air-rifle Piston

a piece of steel with a slot 0.09 inch wide and just deep enough to take one leg, or half the finished piece. A recess across the face, 0.065 inch deep, takes the web when it buckles out, and flattens it into shape. Two pins across the slot in the die locate the piece endwise. Two spring pads in the punch, with vees in the lower ends and keyed to prevent their turning, cause the piece to enter the upper slot.

Fig. 6 shows the third, and final, die, with a blank from the second operation in place ready to be formed. The piece rests

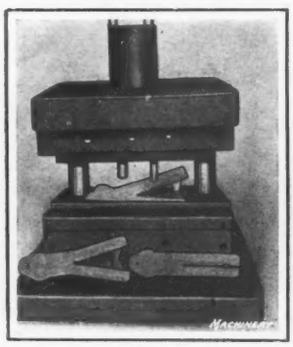


Fig. 5. Punch and Die for obtaining Shape B, Fig. 2

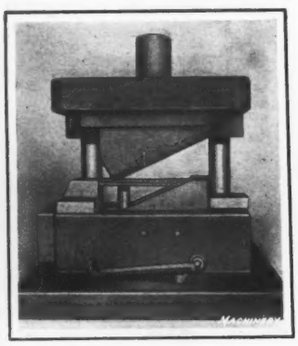


Fig. 6. Punch and Die for finishing Piston

against a guide and on a spring pad at the left, while the folded web drops into a slot in a spring pad at the right. The right-angle bend is made first, and at the bottom of the stroke the half-round body and saucer-shaped end are formed.

* * *

FLEXIBLE TURBINE GEARING

BY MARK MEREDITH [1]

The problem of insuring equal distribution of pressure over the whole surface of the wide fine-pitched gears now coming into use for marine-turbine speed reduction is being tackled in many ways. John H. Macalpine, who was the first to offer a practical solution of the matter, supports the pinion in a rocking, or floating, cradle designed to permit of a continuous self-adjustment of the pinion to the wheel. In one of his arrangements, the frame supporting the pinion is constructed so that the solid metal affords a certain amount of spring whereby, when the tooth pressure becomes unduly heavy on one side of the gears, due to unavoidable imperfections in gear-cutting or lack of alignment of the two shafts, that side yields just enough to allow the pressure to spread equally over the whole face. In another arrangement, the same effect is obtained by sustaining the pinion bearings on interconnected hydraulic pistons. The Macalpine device has been tried on both large mercantile vessels and battleships; and, though there has been a good deal of discussion, the device may be said to have shown its superiority over the usual type of gearing in respect to efficiency, durability, smoothness, silence of working, amount of lubrication required, degree of reduction possible, and weight of gearing set.

Sir Charles Parsons believed the solution lay in eliminating, as far as possible, the inaccuracies that the teeth of all large gears revealed, and set to work to discover and eliminate their source. He arrived eventually at the ingenious methods by which the errors in the master gear of the gear-cutting machine are distributed over the face of the cut gear. By this means a considerable improvement was effected in the working of reduction gears without interfering with the solidity of the pinion-journal supports. But it is doubtful whether even absolute initial accuracy, could that be obtained, would give as good results as some system of automatic continuous self-adjustment. Initial gear-tooth errors are only one part of the derangements of alignments that have to be provided against; there are also the torque of the pinion, gradual wear of bearings, and distortion of gear under varying loads.

A third solution of the problem consists of building up the main gear with a series of disks, chambered at the sides, threaded upon the second-motion shaft. When put together, these disks are in close contact both at the hubs and at the rims, and the built-up gear blank is turned and cut just as though it were a solid gear; but when the cutting is finished, a parting tool is run between each pair of disks, so that the gear in its final working form appears as a row of disks secured rigidly to the shaft and to each other at their bosses, but separate at their peripheries. The teeth are, of course, cut helically. The effect of this construction is that when, in working, undue pressure comes upon any disk at any point of its circumference it deflects sidewise, and thereby allows the load to spread over the rest of the disks. The proportioning of the disks, particularly as regards strength and contour of cross-section, requires careful calculation and experiment in order that the lateral deflection may at no time involve fiber strains, which could possibly cause destructive fatigue, but a very small side movement is sufficient to afford even distribution of load across the entire surface of the gear. This type of flexible disk has been successfully applied to eighty sets of turbo-generators and is being tried as a turbine reduction gear for steamships.

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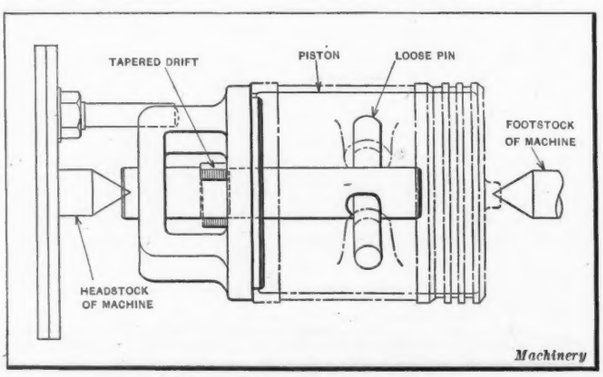
* * *

PISTON GRINDING FIXTURE

The illustration shows a simple and effective means of holding a piston for grinding. Simply slide into place the loose pin that fits snugly into the wrist-pin holes of the piston, slide the back-plate onto the base of the piston, then drive the drift in until all are bound together. It is then ready to be placed on the centers. The driver is furnished by the bridge part of the back end, which engages a driving pin. To remove the piston, knock out the drift and withdraw the pin. All parts of this fixture should be hardened, except the base. In several concerns where this fixture is in use, from twenty-five to thirty-five pistons, 3½ to 3⅞ inches diameter, are produced per hour, removing from 0.025 to 0.030 inch stock to 0.001 inch limit, there being three diameters to grind.

The operation is performed by sizing the body over the entire length, which is the largest diameter. This is done by two methods: by feeding the wheel straight in for a full width cut (no traverse), using a wide wheel, or by stroking the work with a 2-inch wheel. Then grind the two bottom rings, the next largest diameter, with a straight-in cut, and the ring or smallest diameter, also with a straight-in cut, and the piston is finished. Two fixtures are usually used, the operator loading one while the cut is being taken on the piston mounted on the other.—*H. W. Dunbar in Grits and Grinds*



Grinding Fixture with Mounted Piston

ECONOMICAL PRODUCTION OF ACCURATE HARDENED GEARS

METHODS AND FIXTURES USED BY PROGRESSIVE AUTOMOBILE MANUFACTURERS

BY F. B. JACOBS [1]

TO produce hardened spur gears, such as are used in automobile transmissions, economically involves many operations of equal importance, as the quality of the finished product depends on the care exercised in the various stages of manufacture. Not all the operations described here are found in one manufacturing plant, but they are used in the plants of progressive manufacturers of the Middle West. In the manufacture of transmission gearing, the grinding wheel plays an important part; it furnishes a rapid and efficient means of

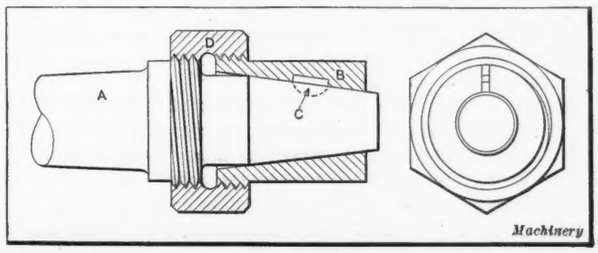


Fig. 1. Nose Arbor for holding Gear Blank when turning Periphery and facing Side

turning out accurate work and also a means for correcting the errors due to the expansion and contraction of the metal during the annealing and hardening processes.

The gear adopted by many prominent automobile manufacturers is made of forty-point carbon steel, and in the process of manufacture goes through five principal stages, *viz.*, machining to rough dimensions, annealing, machining to finish dimensions, oil tempering, and grinding. The first step is to chuck the blank by its largest diameter, bore and ream the hole, and face the hub and one side. This operation is simple and well known; the method used is familiar to every mechanic who has had occasion to watch a Gisholt, Potter & Johnston or other machines used for similar purposes in operation. Due care is, of course, exercised, and the operator is provided with limit gages for maintaining the correct dimensions.

[1]Address: 435 Harvard Place, Indianapolis, Ind.

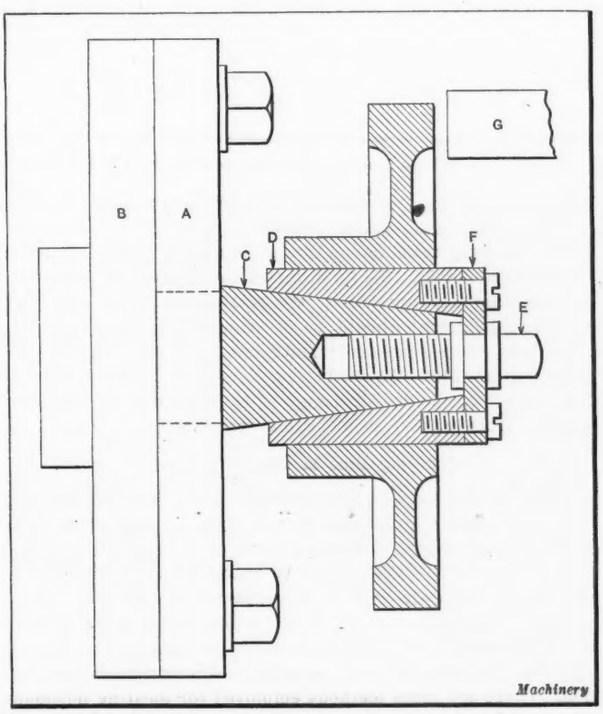


Fig. 2. Fixture for grinding Side of Gear Blanks

The next operation is to rough-turn the periphery and face the other side of the gear. This is generally done on a heavy-duty engine lathe, the blank being preferably held on a nose arbor, as this method facilitates taking heavy

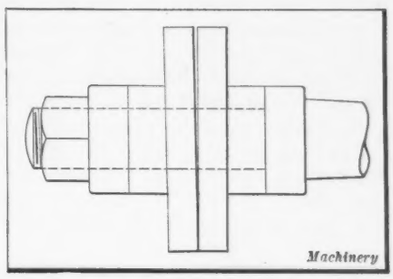


Fig. 3. Result of using Arbors that do not run True

cuts, thus keeping production up to the maximum. A good design of arbor for this purpose is illustrated in Fig. 1. It consists of an arbor *A* with a taper shank to fit the tapered hole in the spindle, an expanding bushing *B*, which is prevented from turning by the key *C*, and a substantial nut *D*, which is provided with a coarse right- and left-hand thread. This is a convenient device, as a half turn of the nut is sufficient to grip the work firmly and the action of the right- and left-hand threads quickly collapses the expanding bushing when the work is to be removed, thus eliminating the necessity of resorting to the lead hammer. The latter tool has its uses, but it has been the means of springing and thus unfitting for accurate use many expanding holding devices that often

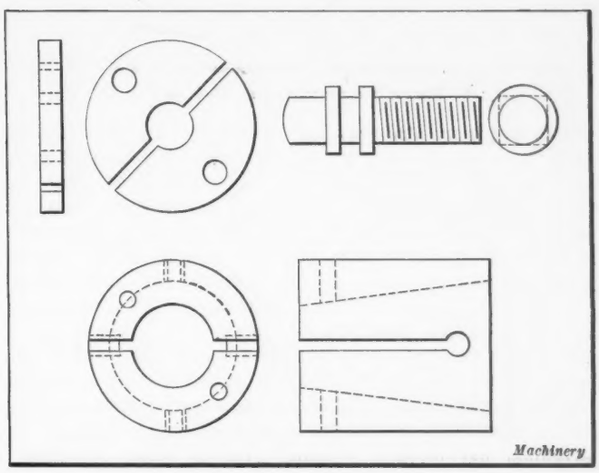


Fig. 4. Details of Fixture shown in Fig. 2

fail to operate readily. This arbor can be made of tool steel or thirty-point carbon steel; in either case, the parts should be hardened to prevent undue wear and the arbor and bushing should be ground to insure accuracy.

To insure quiet-running gearing, so necessary in the modern high-powered car, it is of absolute importance that the teeth be both concentric and parallel with the axis. Through carelessness on the part of the operator, as well as through the use of arbors that do not run perfectly true, it is easy to bring about the condition shown in Fig. 3, which represents two gears placed back to back on a gear-cutting arbor. The sketch is exaggerated to illustrate the error and shows what happens when the sides of the gear are not parallel with the hole. When the nut is tightened the gears are sprung together. Although when in this position the teeth cut are parallel with the axis, as soon as the pressure is removed the blanks spring back to their original position, which results in faulty teeth that are bound to produce an unsatisfactory gear. To eliminate this difficulty, a preliminary grinding operation is brought into play before the teeth are cut.

First, the gear blank is located by its hole and one side of the rim is trued, as shown in Fig. 2, where *A* is a faceplate

fixture which is bolted to the faceplate of a universal grinding machine. Care is taken, of course, to see that it shows true when tested with a dial indicator. The faceplate of the grinder is shown at *B*. The faceplate *A* is provided with a taper arbor *C*, over which is fitted a bushing *D* that carries the gear. The bushing is expanded to grip the gear blank by means of the screw *E* and the collar *F*. The grinding wheel is shown at *G*. For the sake of the tool designer who may wish to utilize this feature, the bushing, collar and screw are illustrated in detail in Fig. 4, which is self-explanatory. As the face grinding is in reality the first finishing operation, it is done after the gear blanks have been annealed.

The next operation is to rough-grind the hole. This is done by locating the blank by the ground surface just finished on the fixture shown in Fig. 5, which consists of a faceplate *A* and three blocks *B* for locating the gear by its periphery.

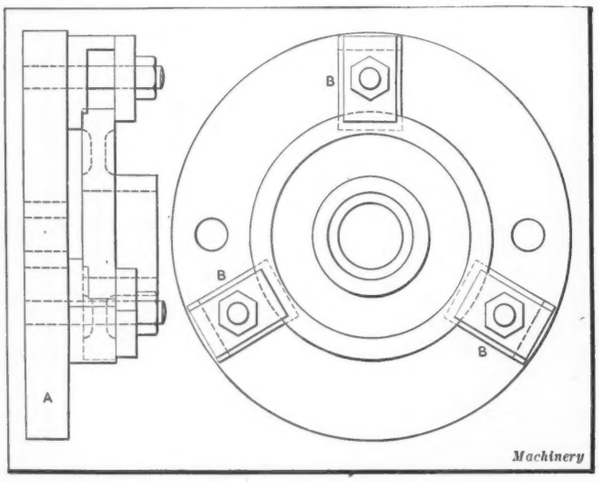


Fig. 5. Fixture for rough-grinding Hole in Gear Blank

Three straps are also provided for clamping the gear in place. This faceplate is bolted to the faceplate of an internal grinding machine, care being used to see that it runs true. The hole is ground to within 0.0001 inch of the finish size, this amount being allowed for grinding after the gear is hardened.

The next operation is to turn the outside diameter of the gear true with the hole. This is generally done with an arbor like the one shown in Fig. 1, although some manufacturers prefer to do this operation on the grinder. As a matter of fact, it can be done on a heavy type of grinding machine in a very efficient manner if a holding device similar to the one shown in Fig. 2 is used. To many it may appear to be an undue precaution to size the outside diameter of a gear by grinding, but modern grinding practice often furnishes a quicker means of removing stock than the engine lathe, within reasonable limits, and the results are generally far more accurate.

Cutting Teeth of Automobile Transmission Gears

The teeth of automobile transmission gears can be cut in three ways: on an automatic gear-cutter of the type carrying but one cutter working on one tooth at a time, although a multiple cutter for cutting two or three teeth at once may be used; on the Fellows gear shaper; or on gear-hobbing machines of the Barber-Colman type. Whatever type of machine

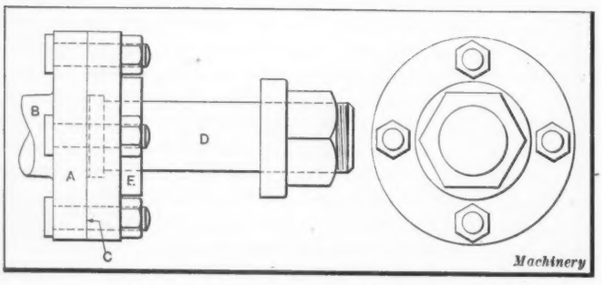


Fig. 6. Gear-cutting Arbor of Novel Design

is used, care should be exercised to see that the arbor for holding the gear blanks runs true when tested with an indicator. This may seem unnecessary to those who expect arbors used on production machines to run out of true a little, but true gears cannot be cut on an arbor that runs out of true. One object of the rough-grinding of the hole is to make a good fit on the gear-cutting arbor, so if the arbor runs out, this precaution is needless.

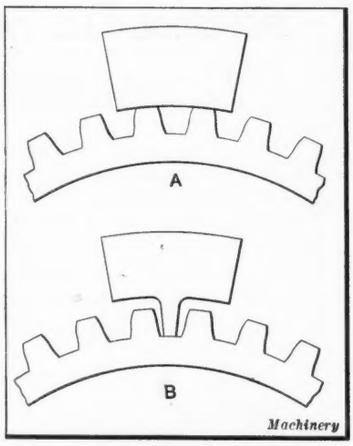


Fig. 7. Two Methods of locating Hardened Gears for grinding Holes

In Fig. 6 is shown a gear-cutting arbor of novel design that is used on a Barber-Colman gear-cutting machine with great success. The faceplate *A*, which is made integral with the shank *B* that fits the taper hole in the spindle, is a machine-steel forging. After being finished, it is driven securely into place, as it is to remain there indefinitely; then the face *C* is carefully finished by grinding. This operation is done with a portable center grinder fastened to the machine for this purpose. It is evident that a surface finished in this manner is bound to run true with the spindle, which is the object desired. The arbor *D* and the inner face of the plate *E* are also finished by grinding, great care being taken to see that they are true and square with each other. Thus, when the two members are securely bolted together by means of the four bolts shown, it is an easy matter to get the arbor to run dead true by means of a dial indicator. Several arbors to accommodate different sized gears can be provided to fit the permanent faceplate, and while it takes a little time to indicate them after placing them in position, the accuracy gained more than compensates for the time spent.

It is not the writer's intention to enter into a long discourse on gear cutting; it will suffice to say that the cutters should

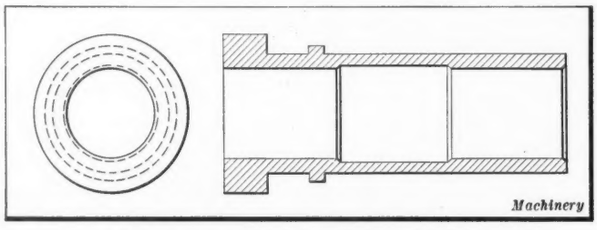


Fig. 8. Quill Gear ground in Fixtures shown in Figs. 9 and 10

be sharp and correctly ground. The depth of the teeth should be kept within close limits, preferably by testing on a vernier gear measuring machine, as this means allows slight errors to be readily detected. While a varied mechanical experience is not necessary to operate a gear-cutting machine, the gear-cutting department should be in charge of a man who has specialized on gearing and understands both the technical and the practical sides. After cutting, the gears are hardened and then tested for the proper degree of hardness and to determine freedom from cracks; they are then ready for the final grinding.

Grinding Hole in Hardened Gears

The production of accurate hardened gears is a difficult problem, but if care is exercised in grinding the hole after hardening, particular attention being given to the manner in which the gear is located in the grinding operation, commercial accuracy is possible even when it is necessary to turn out a large number of gears in a given time. To facilitate production as much as possible, the grinding should be done in an internal grinding machine designed especially for economical production. There are three methods employed for locating hardened gears for grinding the holes: locating the gear by the outside

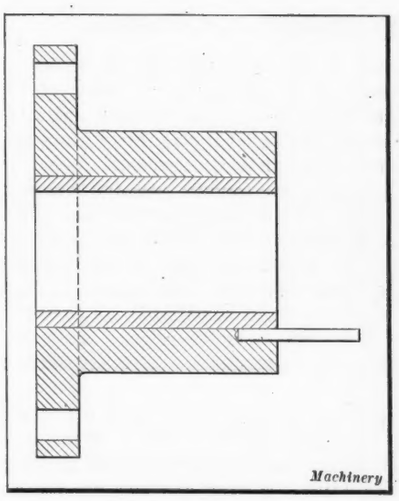


Fig. 9. Chucking Device used in grinding Hole in Gear shown in Fig. 8

diameter as shown at *A*, Fig. 7; locating from the bottom of the teeth, sometimes termed "root control," as shown at *B*; and pitch-line control, as illustrated in Fig. 10. The first-named method would be correct if the gear were not hardened and if it were positively assured that the teeth were concentric with the axis of the gear. The second method would give excellent results on soft gears, provided the bottoms of the teeth were not rough, which is sometimes the case with planed gears, or gears the teeth of which are generated by planing. The third method is an ideal one to use with hardened gears, and if the grinding fixture is correctly designed and constructed, excellent results will be obtained. The pin should be the same diameter as the tooth opening at the pitch line; it could locate a little above or below the pitch line and perhaps cause no harm. The chucking fixture consists of a body *A* which is fastened directly to the faceplate of the grinding machine by means of bolts put through from the back; a split collapsible ring *B* that grips the gear through the medium of eight pins; and a tapered ring *C* that collapses the split ring by screwing into the body of the chuck as shown. The fixture should be carefully made and the tapered rings casehardened and finished by grinding. Care should be exercised to see that the outside of the chuck and the flat wearing surface for the collapsing ring are concentric with each other, as the chuck is indicated to run true by means of a dial indicator each time it is set up on the grinding machine faceplate. If these surfaces are concentric, it is easy to true up the chuck by indicating its outside. The chuck could be provided with a thread and boss for screwing it directly to the grinding machine spindle; experience, however, has proved that the design illustrated is more economical and productive of better work, as it is easy to keep the fixture running perfectly true at all times. The body of the chuck can be made of cast iron, but where many hundred thousand gears are to be made it should be forged out of machine steel and protected from undue wear by casehardening. In this case the thread should be a rather loose fit to allow for errors that are bound to develop in hardening.

The quill gear illustrated in Fig. 8 is comparatively long for its diameter. A good way to finish-grind this gear is to chuck it by its teeth, using the type of fixture shown in Fig. 10 fitted to the plain grinding machine, where the outside diameter is ground to size, the end of the work being supported by a special center. In finish-grinding the hole, it is necessary that the hole be concentric with the outside; otherwise a noisy-running gear will result. The hole is ground on the internal grinder by means of the simple chucking device shown in Fig. 9, which consists of a cast-iron piece bushed with hardened steel. This fixture is strapped to the faceplate

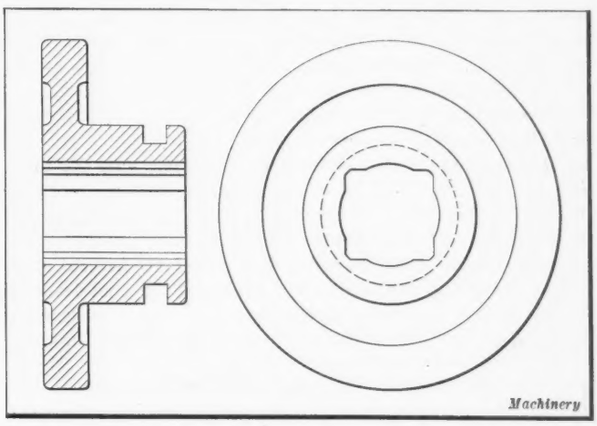


Fig. 11. Square-hole Type of Shifting Gear, which is held in Fixture shown in Fig. 10

of the machine and carefully trued up by means of a dial indicator every time it is placed in position. The hardened bushing should be a nice fit with the gear, which is prevented from turning by a pin, fitting loosely between two of the teeth. The grinding operation is simple in itself, as it does not differ from any other operation of the same kind.

The square-hole type of shifting gear illustrated in Fig. 11 is sometimes considered a difficult piece to machine in cases where accurate, quiet-running gears are desired. Inasmuch as this gear is bound to warp to a certain extent in hardening, it is good practice to grind the hole to bring its axis concentric with the pitch-line circle. To grind a square hole accurately is sometimes considered a difficult and expensive problem, but if a suitable fixture is provided for the work and the operator exercises due care in the grinding operation, satisfactory and economical results are possible.

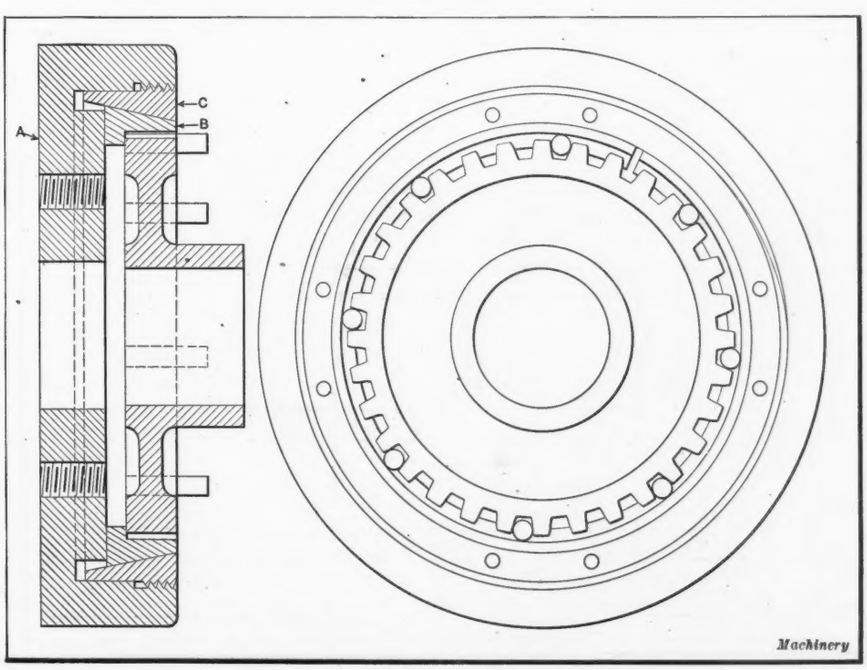


Fig. 10. Fixture in which Gear is located by Pitch Line

The gear, after hardening, is chucked in the type of fixture illustrated in Fig. 10, which in this case is made to fit the faceplate of a Brown & Sharpe or other universal grinder. The grinding wheel fixture used is shown in Fig. 12. It is fastened to the wheel-base platen, if a Brown & Sharpe grinder is used, in the position occupied by the internal grinding fixture, or speed spindle, as it is sometimes called. It is driven by the pulley *A*, which, in turn, drives the wheel-spindle *B* through the medium of a round belt, running over the grooved pulleys *C*. In making this fixture, care should be used in getting dimension *D* correct to bring

the grinding-wheel spindle approximately central with the headstock spindle. Also, dimension *E* should be slightly less than the diameter of the hole to be ground.

To perform the grinding operation successfully, attention must be paid to the wheel speed. In ordinary internal grinding, it is permissible to use a peripheral speed as high as 6000 feet per minute. In the present case, however, where the side instead of the periphery of the wheel is utilized, the surface speed of the outside diameter should not exceed 2500 feet per minute; otherwise the wheel will glaze and burn instead of cutting. The grit and grade of the wheel should be suited to the work, and in ordering these wheels, which are special, the grinding wheel manufacturer should be furnished with full data regarding the work to be performed, type of machine used, finish desired, kind of material to be ground, wheel speed, etc., for this is a special grinding operation and cannot be performed well with wheels picked up at random.

In the grinding operation, the work must be carefully chucked and the wheel brought to bear lightly against the side of the hole away from the operator. The wheel is then fed in and out of the hole by means of the automatic feed until it sparks but faintly. The spindle is then indexed around 90 degrees and another surface ground. After all four surfaces have been ground, the hole is tested for size by means of a square plug gage, and if undersize, a few more cuts are taken. The operator has to work in the dark, as it were, as he has to grind four sides before gaging the work each time; a little practice, however, soon brings about efficient results.

In conclusion, it can be safely stated that the several operations necessary to produce accurate gears of the kind described in this article are really simple in themselves; the secret of success lies in a few simple, accurate tools, as here described.

BRASS FOUNDRY PROBLEMS[1]

With the introduction of oil as a fuel, the utilization of labor-saving machines of all kinds, and the advent of the efficiency engineer and the chemist, brass foundry operation is quite a different proposition to what it was thirty years ago. Still the resourcefulness of foundries is frequently taxed. A proposition recently put up to one foundry was the manufacture, commercially, of duplex thermostatic plates. These plates had to contain, when finished, 50 per cent nickel steel and 50 per cent brass alloy, the nickel steel and the brass plates being cast or otherwise fused together. The brass alloy had to be of such a nature that it could be rolled down to sheets 0.003 inch thick, and even less. Curiously, only one brand of zinc was found that would consistently give satisfactory results in the alloy.

A common foundry problem is when and where to commence using metal patterns for repeat work. Because of the ease with which changes in design may be made, wooden patterns are preferred at the beginning. If these patterns are coated, by means of a Schoop pistol, with copper or lead, they become much better able to resist the wear and tear incident to the molding process.

Another difficult problem is the manufacture of aluminum castings that will take a high polish. Castings made from the standard alloys are invariably full of small black specks, due to gas in the metal; but the addition of from 8 to 10 per cent of tin to the alloy produces satisfactory castings. To make this aluminum-copper-tin alloy, it is necessary to make up a rich alloy and then add bars of it to the aluminum at the proper time.

Tough, perfect, homogeneous brass and aluminum parts are now made by the pressed-metal process. A hot blank is forced into a steel mold of the exact design and dimensions of the desired metal part, powerful hydraulic presses being used. The enormous pressure to which the blank is subjected raises the temperature of the metal and causes it to flow into every part of the mold. By this process, it is possible to make the most intricate shapes; the parts are formed so accurately to size and the surfaces are so smooth that in many cases no machining is required, and the parts are absolutely free from air- and gas-holes and sand. Because of their strength, it is often possible to substitute pressed metal parts for bronze and English gun metal parts.

[1]Abstract of a paper read before the American Institute of Metals in Cleveland, Ohio, September, 1916, by E. A. Barnes.

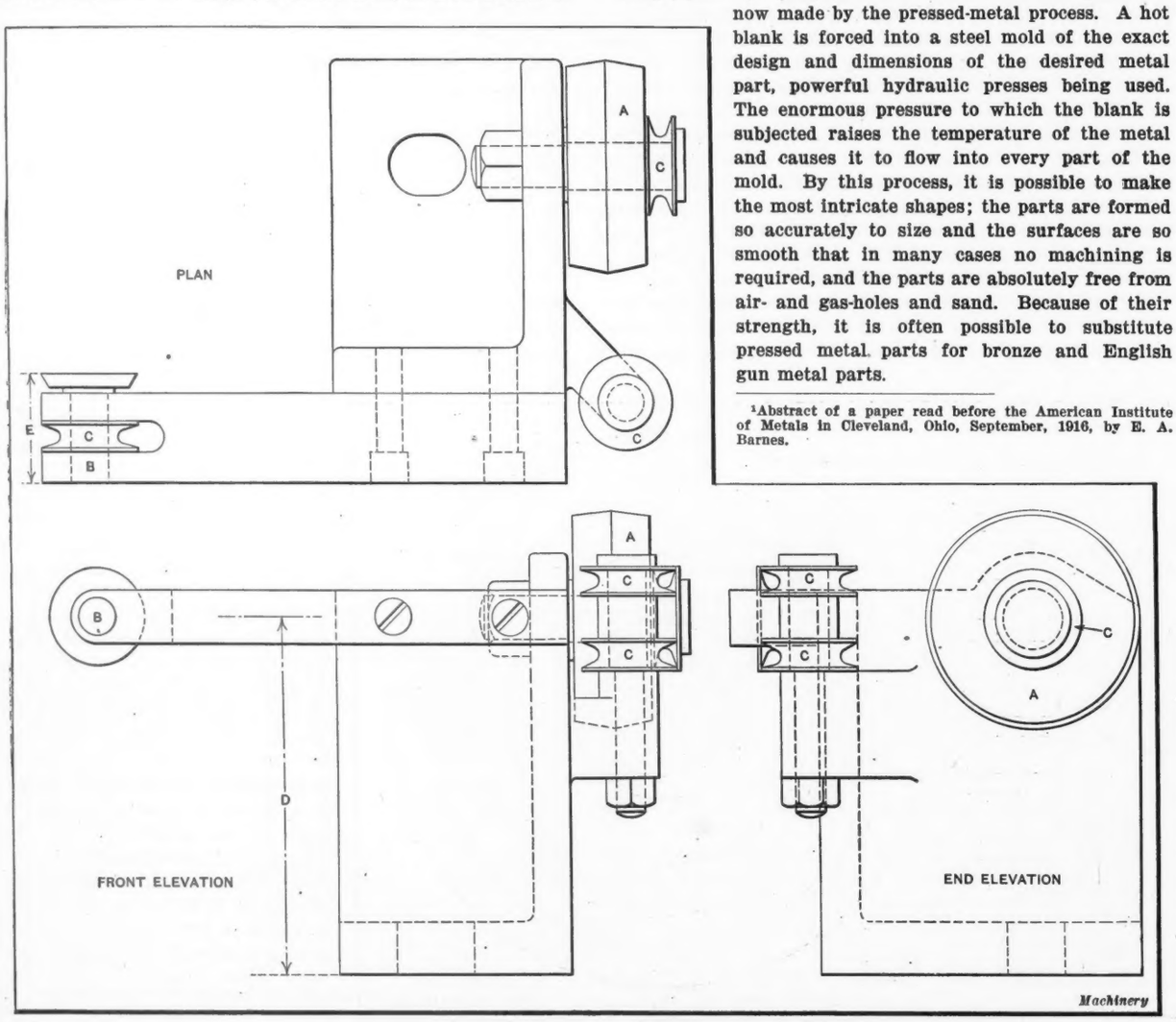


Fig. 12. Grinding-wheel Fixture for grinding Gear shown in Fig. 11

TAPPING MACHINES AND ATTACHMENTS[1]

AUXILIARY APPLIANCES FOR TAPPING ON DRILLING MACHINES—VARIOUS TYPES OF SPECIAL TAPPING MACHINES—METHODS OF HOLDING WORK WHILE TAPPING—TAPPING SPEEDS

BY FRANKLIN D. JONES[2]

THE machines used principally for tap driving include drilling machines, turret lathes, automatic screw machines, and special tapping machines. The type of machine or attachment used for tapping may depend altogether on the relation of the tapping operation to other operations. The number of holes to be tapped and the advantages or disadvantages of doing both drilling and tapping on one machine should also be considered. Regular drilling machines are extensively used for tapping, because the latter operation naturally follows the drilling of the hole. In many cases, the work is so large and cumbersome that there is a decided advantage in tapping it on the same machine used for drilling. The drill press is also used for tapping a great many small parts, but when large numbers of pieces are required, special tapping machines are frequently used. Tapping operations in turret lathes, automatic screw machines, horizontal and vertical boring mills naturally follow the turning, drilling or boring operations in these machines. A special tapping operation is thus avoided and greater accuracy is secured between the tapped hole and other machined surfaces.

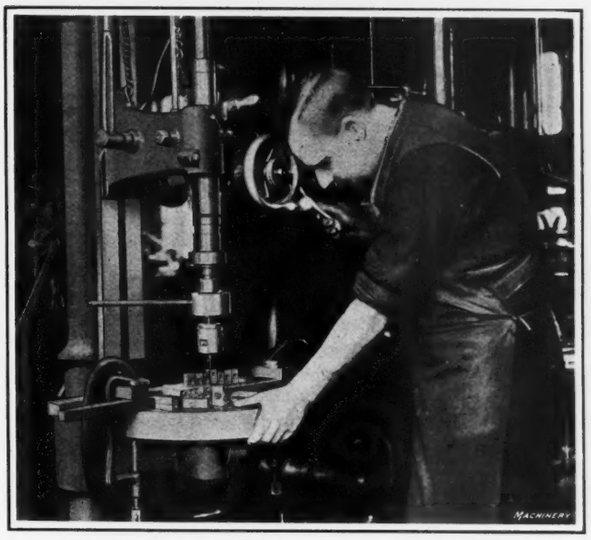


Fig. 1. Errington Automatic-reverse Tapping Chuck in Use on Drilling Machine

Auxiliary Attachments for Reversing Tap Rotation

When drilling machines are used for tap driving, the reverse movement for backing non-collapsible taps out of holes after the thread is cut to the required depth may be obtained either by reversing the spindle of the machine or by using a special chuck or attachment designed to reverse the motion of the tap. Many drilling machines are not equipped with a mechanism for reversing the rotation of the spindle and a special attachment is then required. An automatic-reverse tapping chuck or attachment (manufactured by the Errington Mechanical Laboratory, 39 Cortlandt St., New York City) is shown applied to a drilling machine in Fig. 1. This chuck has a taper shank which is inserted in the spindle of the machine. The body of the chuck and the gage *B* (Fig. 3), which may be used to control the depth to which holes are tapped, are both prevented from rotating with the machine spindle by a rod *A* which, in the case of a drill press, rests against the left-hand side of the machine column and slides up or down the column as the spindle is raised or lowered. When tapping a hole, the regular feed lever or handwheel of the machine is used to lower the spindle as the tap passes down into the hole; when the lower end of stop-rod *B* comes into contact with the face of the work, the direct forward motion drive is released and the tap stops revolving. The machine spindle is then raised; this movement, by the engagement of gearing within the chuck body, causes the tap to back out of the hole rapidly. Raising or lowering the machine table or work would have the same effect. The tap-holder used in conjunction with this automatic reversing chuck may or may not have an adjustable friction drive for safeguarding taps against breakage. For tapping holes in cast iron, brass, etc., or where blind holes are deep enough to prevent the tap from striking the bottom, the frictional form of holder may not be required. The latter is intended especially for tapping in steel or for bottom tapping. This automatic-reverse tapping chuck is sometimes used with advantage for tapping two or more holes at the same time. The exact method of arranging these chucks for multiple tapping operations depends to some extent upon the nature of the work. Fig. 2 illustrates how four holes were tapped in malleable iron gear-cases simultaneously. The chucks are prevented from revolving and are held in the right position by a plate or fixture at the top, which is special for this particular job.

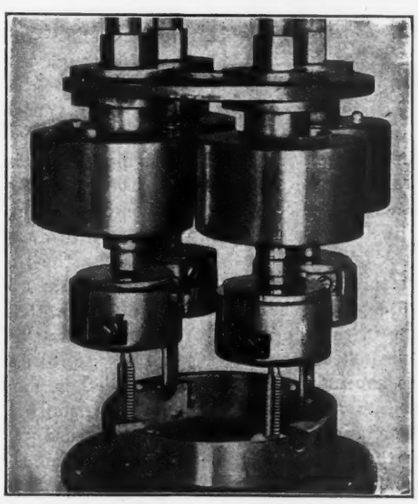


Fig. 2. Errington Multiple Tapper

Tapping Attachments having an Oscillating Movement

When tapping holes in steel and other hard materials with hand-operated taps, it is common practice to alternately advance the tool and then turn it back through part of a revolution in order to assist in breaking up and clearing the chips to prevent breaking the tap. This practice is duplicated automatically in a tapping attachment (see Fig. 4) manufactured by the Wahlstrom Tool Co., 5520 Second Ave., Brooklyn, N. Y. For tapping cast iron and similar materials, this oscillating movement is not required, and for work of this kind, provision is made for disengaging the oscillating drive and engaging a continuous forward drive. This change is made by turning the knob seen in front of the attachment. When either the oscillating or continuous forward drive is used, the tap is backed out by raising the lever that controls the hand feed of the drilling machine spindle. This results in positively clutching a continuous drive that backs out the tap at high speed. A special chuck furnished with the attachment grips the round shank of the tap as well as the squared end, so that the shank is supported right down to the end of the chuck.

Variable-speed and Reversing Attachment

The attachment illustrated in Figs. 5 and 6 has three forward speeds and a reverse motion, and it is adapted either for tapping operations or for speeding up small drills. The speed changes are controlled by turning the knurled knob at the front, which is provided with a suitable handle or lever that also serves to reverse the motion. Fig. 6 illustrates the geared speed-changing mechanism.

[1] For information previously published on this subject, see "Taps and Tapping Equipment," in the November number of MACHINERY, and article there referred to.

[2] Associate Editor of MACHINERY

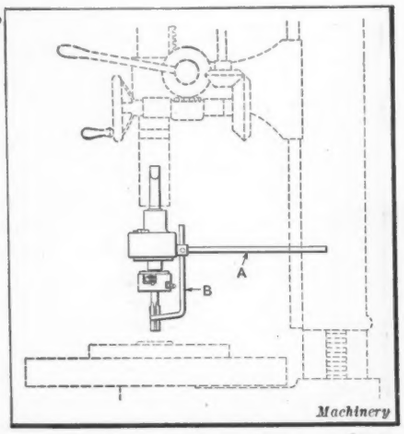


Fig. 3. Diagram illustrating General Arrangement of Errington Automatic-reverse Tapping Chuck and Application to Drilling Machine

These changes are effected by means of two positive clutches, which are shifted by turning the knurled knob referred to. When using the slow or direct speed for tapping or driving large drills, the gears run idle, the direct speed being the same as the spindle speed. Fig. 7 shows this attachment applied to a drill press. A bar extends from the attachment to the column of the machine to prevent the attachment from rotating with the spindle. The variable-speed feature makes it possible to drive a small drill at high speed, a large drill at the low or direct speed, whereas the reversal of motion may be used for backing a tap out of the hole after the tapping operation. The tapping may also be done at a slow speed and the tap backed out at a higher speed. This attachment is made by the McCrosky Reamer Co.

Tapping Mechanism of Drilling Machines

The tapping mechanism of a drilling machine for use with non-collapsing taps, may be arranged not only to reverse the rotation of a tap for backing it out of the hole, but also to safeguard the tool against excessive torsional stresses by means of an adjustable friction located somewhere between the tap and the source of power, which slips in case an unusual amount of resistance is encountered. A frictional chuck may be used for this purpose, or an adjustable friction may be introduced somewhere in the spindle driving mechanism of the machine. A tap reversing mechanism of the kind that is incorporated in the design of the machine instead of being in the form of an auxiliary attachment is shown in Fig. 8. This tapping attachment (which is applied to some of the vertical drilling machines made by the Cincinnati Bickford Tool Co.), when used in conjunction with the friction back-gear, provides for drilling at a fast speed, tapping at a reduced speed, and then backing out the tap at a relatively high speed. Motion is transmitted through the lower bevel gear shown, when tapping, and through an intermediate spur gear and the upper bevel gear for backing out the tap. The intermediate spur gear is mounted on a sector, so that it can be disengaged when not required for tapping. The forward and reverse motions are controlled by the lever shown, which operates a friction clutch connecting with the bevel gears previously referred to. The method of operating this attachment is to start the spindle backward at the same speed as that for tapping until the tap frees itself, and then the speed is greatly accelerated by a pull on the friction back-gear lever. The illustration shows the attachment with the gear guards removed. While tapping attachments on various makes of drilling machines differ somewhat as to their general arrangement, these variations usually pertain to details of construction, and as they all operate on the same general principle, other designs for upright drilling machines will not be described.

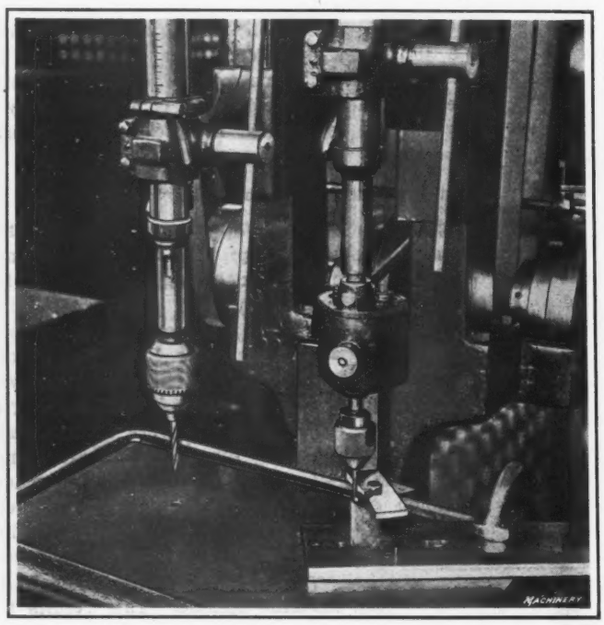


Fig. 4. Wahlstrom Tapping Attachment designed to give Tap an Oscillating Movement when tapping Steel

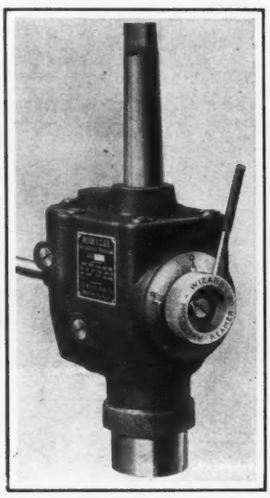


Fig. 5. "Wizard" Variable-speed and Reversing Attachment

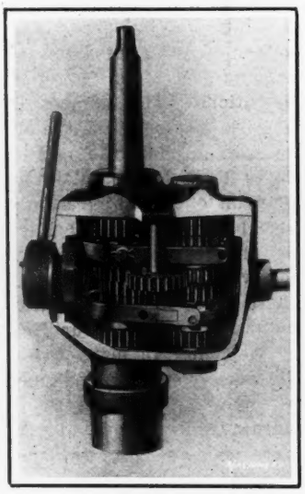


Fig. 6. Interior Mechanism of "Wizard" Variable-speed and Reversing Attachment

On radial drilling machines the mechanism used for tapping and commonly known as the "tapping attachment" is incorporated in the design of the drill spindle headstock. This mechanism, like that applied to an upright drilling machine, is simply a combination of gearing through which motion is transmitted for reversing the roation of the tap. The tapping attachment of the Fosdick radial drilling machine (Fosdick Machine Tool Co., Cincinnati, Ohio) is shown in detail in Fig. 9 as an example of this class of mechanism. Forward and reverse motions are obtained through the combination of three bevel gears shown. This reverse mechanism is mounted on the horizontal driving shaft *A*, which extends along the radial arm. The direction in which the driven shaft *B* revolves depends upon whether motion is transmitted through gears *C* and *D* or *E* and *D*. Either of the two bevel gears *C* or *E*

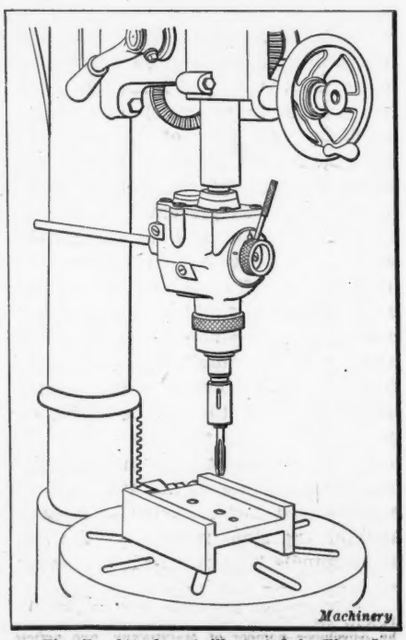


Fig. 7. Attachment illustrated in Figs. 5 and 6 applied to Drilling Machine

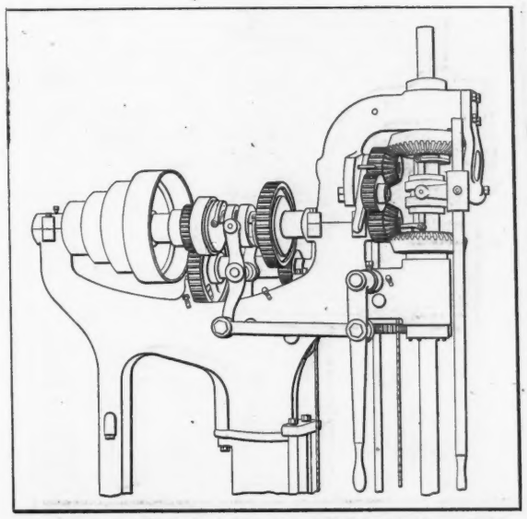


Fig. 8. Tapping Attachment of Upright Drilling Machine

is engaged with the driving shaft by means of expanding ring clutches controlled by a lever or handle located at the right of the lower end of the drill spindle. Motion is transmitted to the drill spindle through back-gears which give three forward and three reverse speeds, with ratios of three to one and nine to one. This back-gearing is controlled by a lever located at the left of the spindle. With this arrangement, taps may be backed out at the same speed as is used for tapping, or at three times or nine times the tapping speed, without changing the regular speed-changing mechanism of the machine.

Special Tapping Machines

Tapping machines may be intended either for general tapping operations or for use on one class of work, like the tapping of nuts. The designs vary considerably, including vertical and horizontal designs in single- and multiple-spindle types. The spindles may be adjusted on some machines for varying the center-to-center distance, or they may be fixed in the case of machines used exclusively for tapping duplicate parts. Tapping machines also vary in regard to the mechanism for obtaining the forward and reverse motions of the tap spindle and the method of controlling these motions. A common arrangement for obtaining the two motions is by means of a clutch which is interposed between two pulleys revolving in opposite directions and is alternately engaged with these pulleys. The clutch may be controlled by (1) a hand-lever connecting with the clutch; (2) a foot-lever connecting with the clutch; (3) pushing the work and its fixture forward until contact is made with a stop-rod or lever which shifts the clutch for backing out the tap; (4) pushing the work against the tap while tapping and by pulling in the opposite direction for backing out the tap, the clutch being shifted by the direct thrust from the part being tapped and the resulting longitudinal motion of the tap spindles. The latter method is applied only to machines used for the lighter classes of work. The characteristic features of well-designed tapping machines are convenience of control and, for small tapping operations, a sensitive drive that will transmit enough power for operating the tap under normal conditions but not enough to break it in case the resistance to rotation becomes excessive. Several different makes of tapping machines will be described to illustrate variations in design.

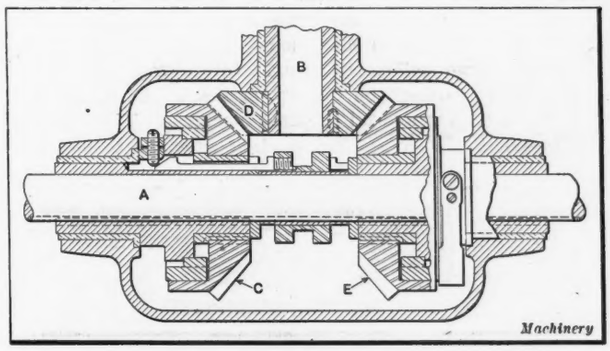


Fig. 9. Mechanism of Radial Drilling Machine for reversing Motion when tapping

Tapping Machines of Horizontal-spindle Type

A simple form of tapping machine, made by the Garvin Machine Co., New York City, is shown in Fig. 10. This machine has two belt pulleys driven by open and cross belts, so that they revolve in opposite directions. A clutch is located between the pulleys for controlling the forward and reverse motions. The parts to be tapped are supported by a pad *A* and are held, preferably, in a socket type of fixture designed to prevent the work from revolving with the tap and to permit rapid insertion and removal of the work. The part to be tapped is moved up into contact with the tap by hand-lever *B* connected to the tailstock spindle. The depth to which the tap enters the hole is controlled by an adjustable stop *C*. When this stop engages the tailstock, thus arresting the forward movement of the tailstock spindle, the tap immediately draws the tap spindle forward and disengages the clutch. When the feed lever is moved in the opposite direction the tap spindle is shifted over still farther, thus engaging the clutch with the reverse pulley, which is narrower than the driving or forward-motion pulley and is located nearer the chuck. This particular machine (which is the No. 2 size) has a capacity for taps varying from 3/16 up to 1/2 inch in diameter.

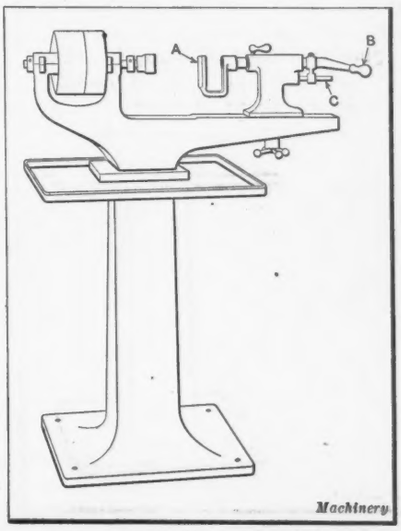


Fig. 10. Garvin Horizontal Tapping Machine

Another design of horizontal, single-spindle tapping machine is shown in Fig. 13. This machine (manufactured by the Rickert-Shafer Co., Erie, Pa.) derives its forward and reverse motion from a combination of three friction wheels, consisting

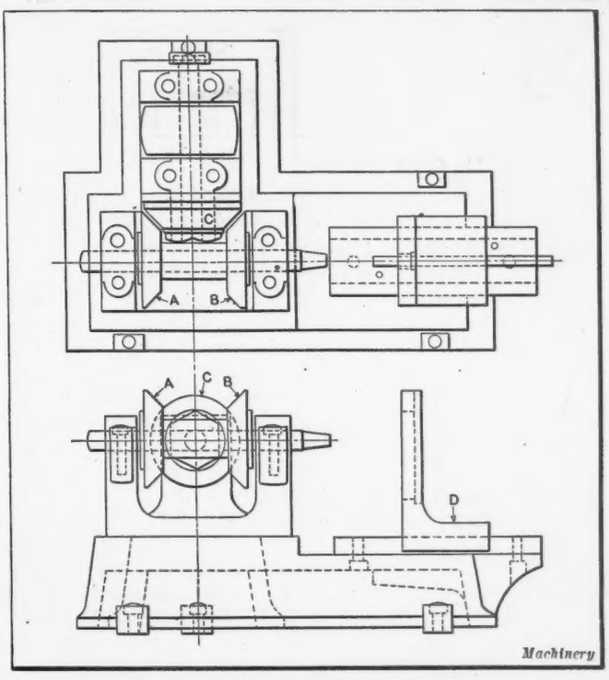


Fig. 11. Meriden Horizontal Tapping Machine

of two drivers and one driven wheel, which is alternately engaged with the driver. The driven wheel *A* is made of aluminum and is located between the driving wheels *B* and *C*, which have friction board driving surfaces. When the part to be tapped is pushed against the tap, the driven wheel is held against the rear driving wheel *C*, which is larger than *B* and revolves at a slower speed. As soon as the hole has been tapped to the required depth, a backward pull of the spindle forces the driven wheel *A* into contact with driving wheel *B*, thus reversing the direction of rotation and backing out the tap. This machine is driven by a single belt, which passes over the forward and reverse motion driving pulleys, as the illustration shows. These two wheels rotate, of course, in the same direction, but the driven wheel is reversed, because it engages pulley *B* on the rear side and pulley *C* on the front side. A work-holding fixture is not used for the particular tapping operations illustrated, because the tap first passes through a clearance hole which holds it in alignment, so that it is not necessary to provide means for holding the work, which is simply applied directly to the tap.

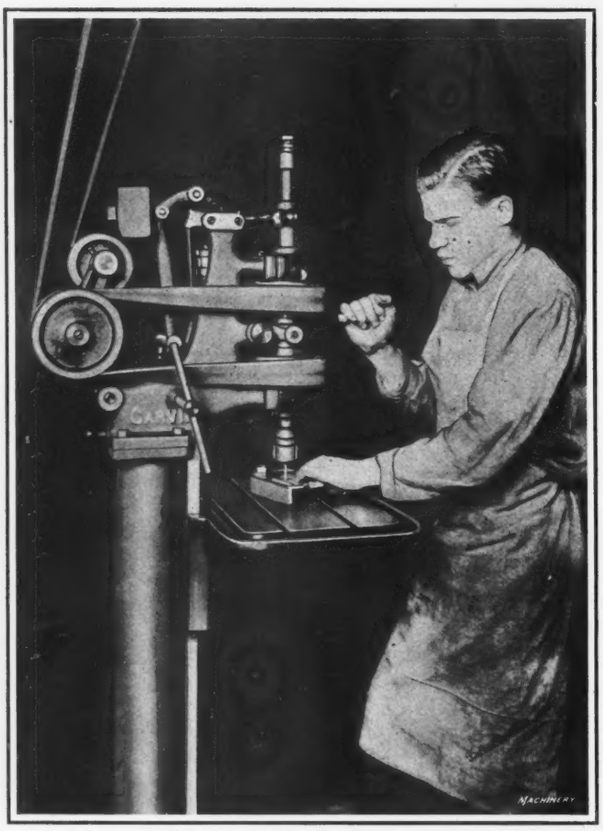


Fig. 12. Garvin Vertical-spindle Tapping Machine

The horizontal tapping machine illustrated in Fig. 11 (built by the Meriden Machine Tool Co., Meriden, Conn.) operates on the same general principle as the one just described, but differs in regard to the arrangement of the driving mechanism. The tapping spindle carries two bevel or conical faced wheels *A* and *B*, which are alternately engaged by a third conical faced wheel *C* mounted on the belt-driven driving shaft. The tap-carrying spindle has a free longitudinal movement, and when a piece of work is forced against the tap, the forward cone *B* is held in contact with the driving cone, thus causing the tap to revolve. When the tap has entered to the required depth and the work is pulled backward, the rear driven cone *A* is brought into contact with the driving cone *C*, thus reversing the rotation of the tap. The two driven cones are made of cast iron and the central driving cone is of cast iron faced with leather to increase the frictional resistance. The machine has a slide *D*, which is mounted on V-shaped ways, and is intended to hold whatever form of fixture may be needed. The slide has an adjustable stop-rod which limits the travel or movement of the work toward the tap. This machine is

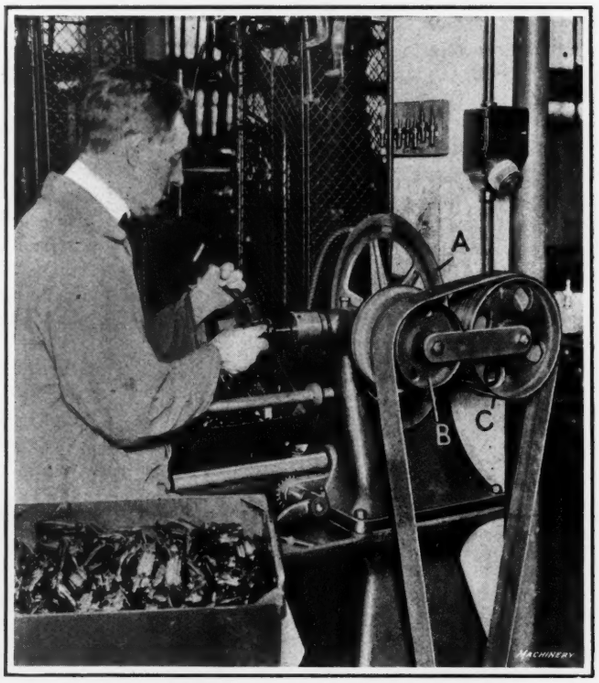


Fig. 13. Rickert-Shafer Horizontal Tapping Machine

designed for tapping holes 1/4 inch in diameter or less. The horizontal tapping machines of the type previously described are adapted especially for small parts which are easily handled.

Vertical-spindle Tapping Machine

For many classes of work a machine with a vertical spindle is preferable to the horizontal type. One of the Garvin tapping machines of the vertical type is shown in Fig. 12. The spindle carries two belt pulleys which are driven in opposite directions by one continuous belt. A friction clutch between these two pulleys is brought into engagement with one pulley for starting the tap, by means of the operating hand-lever or by a foot-pedal on some machines. The connection between this lever and the friction clutch is through a

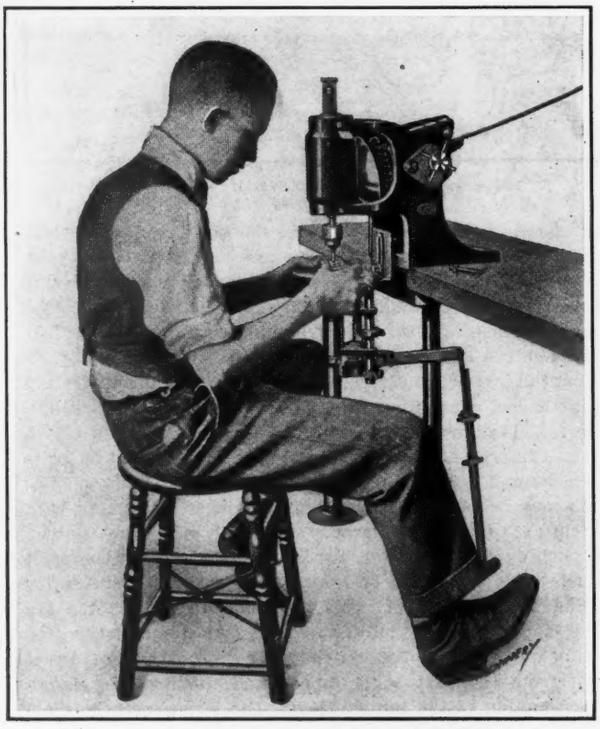


Fig. 14. Anderson Vertical-spindle Tapping Machine

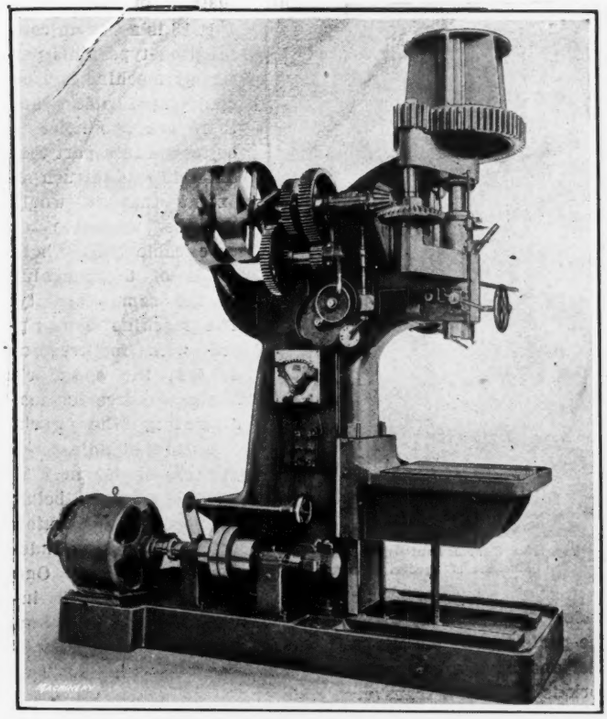


Fig. 15. Baker Sixteen-inch Tapping Machine

mechanism which provides an adjustment for varying the tension in order to safeguard taps against breakage. After the tap is started the machine operates automatically, the tap feeding down to whatever depth the machine is adjusted for and then backing out of the tapped hole. The point at which the reversal of the tap spindle occurs is controlled by an adjustable screw stop on the upper end of the spindle. This screw stop strikes a tripping lever on top of the machine and shifts the friction clutch located between the two friction pulleys. Fixtures for a machine of this general type should be so designed that the work will not be lifted by the screwing action of the tap.

The vertical-spindle tapping machine illustrated in Fig. 14 has a spherical friction driving disk which is mounted directly on the armature shaft of the motor. The tapping spindle carries two rollers, one being above the center of the driving disk and the other below it. The rotation is reversed by engaging the disk with first one roller and then the other. The motor is pivoted in the frame of the machine at the center of the spherical face of the friction driving disk. By inclining the motor and armature shaft to various angles, changes in the tapping and return speeds may be secured. With this arrangement, if the speed is reduced in one direction it will be increased in the opposite direction. For instance, if the spherical driving disk is so located that the spindle makes 1000 revolutions per minute in the forward and reverse directions and the position or adjustment is then changed to reduce the tapping speed to 500 revolutions per minute, the reverse movement will be increased to 1500 revolutions per minute. The work-table of this machine is moved upward by means of a foot-treadle, as the illustration shows, for bringing the work into contact with the tap. The connection from the floor to the machine is adjustable and is provided with a safety spring so that the leading movement of the tap will not be affected by a sudden application of pressure on the foot-treadle. The weight of the table is counterbalanced by an adjustable spring which gives a sensitive control of the table movement. The column supporting the table is hollow and may be filled with oil so that when tapping parts which permit the tap to go through the hole, the tap will dip into the oil. In this way, the tool is automatically lubricated and the chips washed off the end so that they will not injure the thread when the tap backs out of the hole. As this oil chamber gradually fills with chips, the oil level is automatically maintained. A spring at the upper end of the spindle can be adjusted to counterbalance the spindle weight. This machine is capable of tapping holes in cast iron ranging from 1/16 to 1¼ inch in diameter and for tapping holes in steel varying from 1/16 to 3/16 inch in diameter. The maximum depth to which holes may be tapped is 1½ inch. This tapping machine is built by the Anderson Die Machine Co., Bridgeport, Conn.

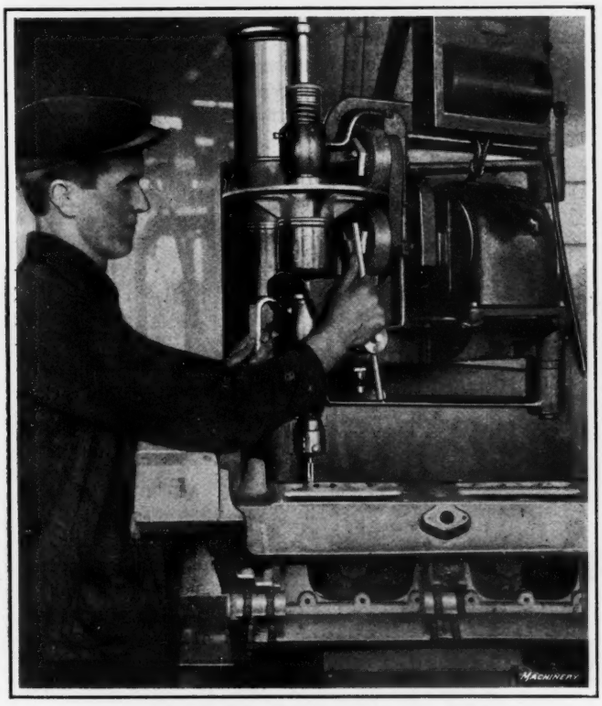


Fig. 16. Rickert-Shafer Tapping Machine of Radial Type

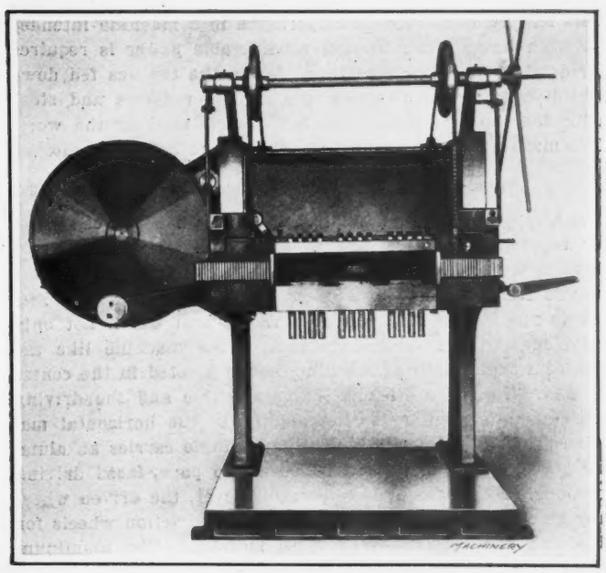


Fig. 17. Moline Multiple-spindle Tapping Machine

One of the large tapping machines made by Baker Bros., Toledo, Ohio, is illustrated in Fig. 15. This is a 16-inch size and is designed to tap cast-iron pipe fittings varying from 2½ to 16 inches in diameter. This machine is semi-automatic in its action, the reversal of the tap being controlled by means of a pneumatically operated reversing mechanism. The spindle is fed downward, when tapping, through change-gears which positively control the advance movement of the tap. These gears may be arranged for tapping either 8 or 11½ threads per inch, which covers the pitches of pipe threads for which the machine is intended. One of the interesting features of this machine is the method of driving the spindle. Attached to the top of the spindle there is a

cross-arm, the ends of which engage vertical slots in a gear-driven driving head. This head is rotated through a pinion attached to a vertical shaft which connects through bevel gearing with a horizontal shaft that may be driven from the belt pulley shown, either direct or through back-gearing. As the driving head engages the outer ends of the cross-arm on the spindle, there is a relatively low unit pressure on the bearing or driving surfaces; consequently, the frictional resistance to a vertical movement of the spindle is reduced and the spindle follows the tap more readily than it would if the drive were through a key or spline connecting directly with the spindle. This feature is of especial importance in a machine intended for such heavy work because considerable power is required for driving the large pipe taps. When the tap has fed down to the exact depth required, the spindle reverses and stops after the tap has locked out far enough to clear the work. This machine is also adapted to drilling and boring operations.

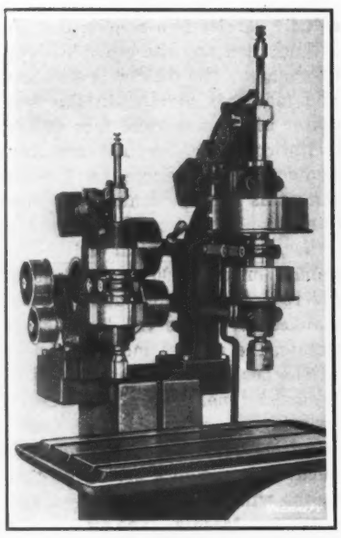


Fig. 18. Garvin Combination Tapping Machine

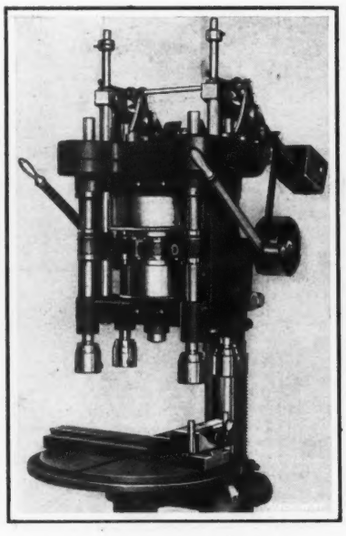


Fig. 19. Garvin Four-spindle Tapping Machine of Special Design

Vertical-spindle Tapping Machine of Radial Type

The tapping machine to be described is adapted especially for tapping parts that are so large and cumbersome that there is a decided advantage in being able to move the tap spindle from one hole to another. The tap spindle (see Fig. 16) is mounted at the end of a radial arm which not only swivels about the vertical column of the machine like the arm of a radial drilling machine, but is pivoted in the center as well. This is a Rickert-Shafer machine and the driving mechanism is similar to that applied to the horizontal machine previously described. The tap spindle carries an aluminum disk which is located between two paper-faced driving frictions. By means of the operating lever, the driven wheel may be engaged with either of the driving friction wheels for obtaining the forward or reverse motions. The aluminum driven disk has about the same coefficient of friction as cast iron, but its centrifugal force is only about one-third as great. The radial arm is supported by the vertical column. The driving motor is carried by the outer section of the pivoted arm and it drives the friction wheels through gearing. This machine will tap any hole within a radius of 48 inches and by folding the radial arm, the tap may be located within 8 inches of the column. The machine has a capacity for holes in steel varying from 1/4 to 1/2 inch and for holes up to 5/8 inch in diameter in cast iron.

Multiple-spindle Tapping Machines

Multiple-spindle tapping machines are usually intended for special classes of work, although they are sometimes arranged for general tapping operations. The two-spindle machine illustrated in Fig. 18 is a Garvin combination type. This particular machine is especially applicable when there are two holes to be tapped in a part that differ in size to such an extent that it would not be advisable or practicable to have both heads of the machine of the same capacity. The machine is equipped with foot-treadles so that the operator's hands are free for manipulating the work.

A four-spindle machine is shown in Fig. 19, the spindles being operated in pairs which are controlled by independent levers. One pair of spindles is intended for rough-tapping, and the other pair for finishing. The parts tapped on this particular machine are made of tool steel and have a comparatively deep hole to be tapped. The work is held by a transverse slide or fixture which, after the rough-tapping, is simply moved over to locate the holes under the finishing taps. The general operation of these two machines is the same as that of the regular Garvin tapping machines previously described.

The special multiple-spindle tapping machine illustrated in Fig. 17 was made by the Moline Tool Co., Moline, Ill., for performing multiple tapping operations on automobile cylinders which are cast in block and for a variety of other tapping operations of the same general class. The spindles of this machine are driven from the large crank at the left which connects through a rod with a horizontal rack from which motion is transmitted to the spindles through pinions meshing with the rack. The crank gear, which drives the reciprocating rack, is driven through a train of spur and spiral gears which receive motion from a shifting belt. The upper end of each tap spindle has a shell lead-screw of the same pitch as the tap. The part to be tapped is held either on a wheeled jig or on the table. The cross-rail is lowered against a positive stop for locating the ends of the taps in position for entering the holes in the work. When the machine is started, the crank gear makes one complete revolution which causes the taps to feed downward a predetermined distance and then withdraw, after which the machine is stopped by a brake. This crank and rack control is employed when it is necessary to tap to an exact depth. A machine of this type may have either fixed or adjustable tap spindles. This is, of course, a special design and ordinarily would be constructed to meet the particular requirements of a given class of work.

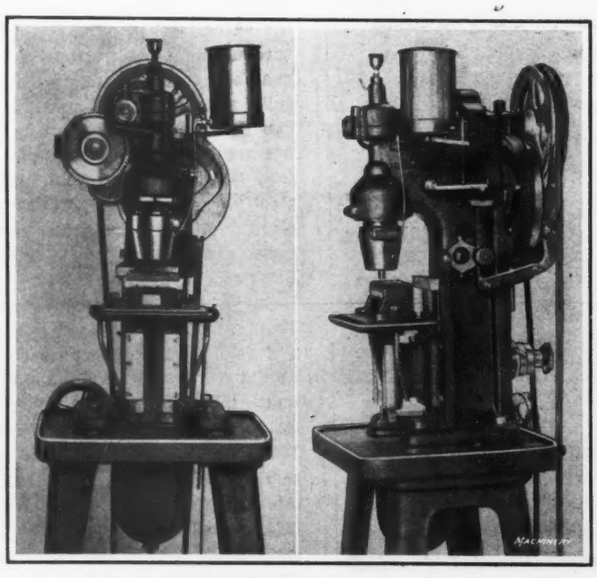


Fig. 20. Langelier Semi-automatic Multiple-spindle Tapping Machine

Semi-automatic Multiple-spindle Tapping Machine

The multiple-spindle tapping machine illustrated in Fig. 20 has spindles located fixed distances apart and is intended for tapping large numbers of duplicate pieces. The machine may be adapted for tapping almost any number of holes grouped within

a five-inch circle. The head carrying the tap spindles is arranged to suit the work. Each spindle is fitted with a special compensating device which allows every tap in the head to follow its own lead. This feature also permits operating taps of different pitches simultaneously. The main spindle is driven through spiral and spur gearing from a set of three grooved pulleys mounted side by side at the back of the machine near the top. The inner of the three pulleys drives the taps forward and operates the mechanism which raises the machine table at the proper rate for the pitch of tap being used. The outer pulley reverses the taps and also lowers the table at twice the tapping speed. As soon as the taps clear the work or jig, the machine stops automatically for a long enough period to permit removing the tapped piece and inserting another blank. The driving belt is then shifted mechanically and the cycle of operations repeated. The central pulley is an idler to which the belt is shifted for stopping the machine. This shifting of the belt is controlled by a pilot gear which is driven through change-gears. Adjustable dogs on this pilot gear operate the belt-shifting fork. One dog shifts the belt to the idler pulley for stopping the machine and the other one shifts it to the outer pulley for reversing the motion of the taps and the table movement. The position of the dog that shifts the belt to the loose pulley remains the same, but the reverse dog is set with reference to the thickness of the part being tapped. The vertical motion of the table is derived from a face cam formed on the side of the pilot gear. This machine is the product of the Langelier Mfg. Co., Providence, R. I.

Fig. 21. Acme Six-spindle Nut-tapping Machine

Nut-tapping Machines

Some of the most highly developed and ingenious tapping machines are used for tapping nuts. These machines are made in reversing and non-reversing types and may be hand-operated, semi-automatic, or fully automatic. Reversible machines are used for tapping nuts having closed ends which make it necessary to reverse the tap and back it out. The non-reversible machines may be so arranged that the nuts pass onto a long tap shank from which they are removed periodically, or the tap may be so held and driven that the tapped nuts pass over it completely without removing it or stopping the machine.

The six-spindle nut-tapping machine illustrated in Fig. 21 is manually operated, a foot-treadle being used to raise the tap spindle each time a blank is inserted under the tap, which is done by hand as the illustration shows. The spindle and tap feed downward by their own weight and meanwhile the operator is inserting a blank nut beneath the next successive tap, so that the machine operates continuously. The vertical tap spindles carry gears which mesh with long pinions, allowing the spindles to be raised or lowered without interfering with the drive. A lever that projects outward in front of each spindle is used for controlling the drive, and enables any one spindle to be stopped independently of the others if necessary. This machine may be used for tapping either square or hexagon nuts. While nut tappers of this general type have been used extensively, the semi-automatic design to be described represents a more modern type.

Semi-automatic Nut-tapping Machine

The semi-automatic nut-tapping machine is so arranged that vertical movements of the tap spindles are controlled mechanically instead of manually. When the six-spindle machine illustrated in Fig. 24 is in operation, the square or hexagonal nuts, as the case may be, are placed by the operator in adjustable chutes. Each of these chutes or magazines holds a sufficient number of nuts to supply the tap which it feeds for some time. The chutes are placed in front of the machine, above the nut storage space provided in the bed, and are at an angle of from 30 to 45 degrees with the axis of the tap spindle, and a distance to the right depending on the size of the nut. On the top end of each tap spindle and revolving with it is mounted a special form of hardened steel worm. This worm performs the work of raising the spindle. When the spindle and tap are in the lower position, caused by the tap feeding through the nut, a finger or key is automatically projected into the space between the worm threads. The finger is stationary in the vertical plane and the worm engaging it travels upward and raises the spindle a distance equal to the length of the worm cylinder. The spindle and tap are then lowered and the tap enters the blank nut, which is in position under and in line with the tap.

An arrangement of adjustable counterweights almost balances the weight of the tap spindle, so there is no appreciable shock imparted to the tap when entering the nut. The nut is delivered from the base of the chute to the tapping position, by a swinging arm that derives its movement from the mechanically lifted tap spindle. This swinging arm carries a relief device, so that in the event of any obstruction in the

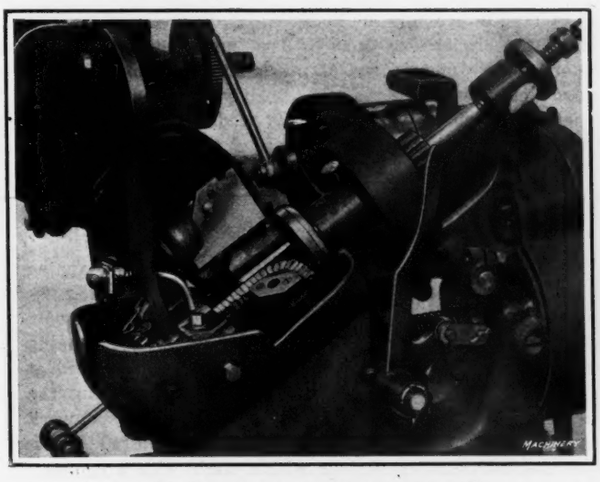


Fig. 22. National Automatic Nut-tapping Machine

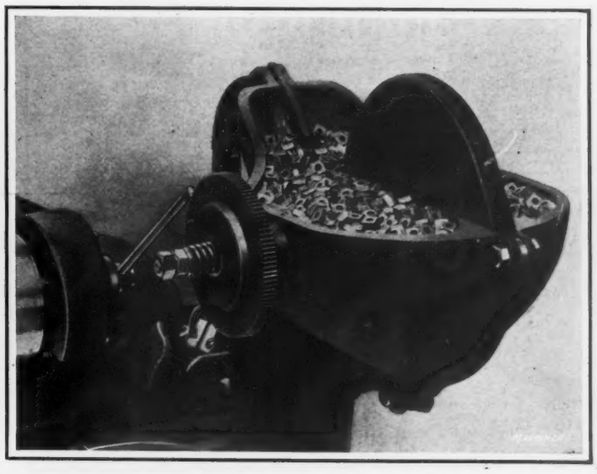


Fig. 23. Hopper from which Blank Nuts are fed automatically

path of the nut, the parts delivering the nuts are relieved from undue strain. When the tap shank is filled with nuts, the spindle automatically ceases to rise, but continues to revolve. This function is controlled by the tapped nuts on the shank of the tap, so that the tap spindle continues to rise after each nut is tapped until the tap shank is filled. The operator then raises the spindle with the foot-treadle, removes the tap from its socket, empties the nuts from the tap shank and returns the tap to the socket; the work then continues automatically. The sockets or chucks for holding the taps are designed to permit rapid insertion or removal.

The automatic feature of raising the tap spindle and delivering the blank nut to the tap is an individual one with each spindle, so when the operator is removing nuts from one tap, the other spindles continue to work automatically. A small latch or lever attached to each spindle enables the operator to discontinue the automatic lifting function on one or more spindles if desired. The nut-holder plates are fitted with adjustable hardened steel blocks that can be adjusted to suit any size nut within the range of the machine. The front block is attached to the adjustable chute and the chute is fastened to the holder plate. The gear through which each spindle is driven meshes with a long driving pinion and moves vertically over the face of the pinion. This produces an action free from tendency to raise the nut from the holder plate during the tapping operation. Power is transmitted to the machine by means of cone pulleys, giving a range of speeds necessary for each size nut within the capacity of the machine. A suitable compound is supplied by a rotary pump, each tap having an individual spout and control cock. The machines shown in Figs. 21 and 24 are manufactured by the Acme Machinery Co., Cleveland, Ohio.

Automatic Tapping Machine of Bent-tap Type

Many attempts have been made to design tapping machines that would operate automatically and continuously. The principal problem has been to separate the tapped nuts from the tap without removing the tap from its holder. One method of securing continuous operation and avoiding the reversal of the tap spindle is by the use of a tap having a bent or curved shank. This shank is curved to form a right-angle bend of rather large radius and it is held in a groove in the tap-holder. This groove is large enough to allow the tapped nuts to slide over the shank. The right-angled bend of the tap shank causes the tap to revolve with the spindle and the tap is steadied by the nuts which are continually passing over the shank when the machine is in operation. An automatic nut-tapping machine in which the bent tap principle has been utilized successfully is illustrated in Figs. 22 and 23. In Fig. 22 the tap-holder is opened to show how the tapped nuts pass over the curved tap shank before being ejected at the end. The nut blanks are fed automatically from a hopper (see Fig. 23) down through a chute to the tap. The nut blanks are delivered from the hopper to the feed chute by means of a vane feed and they are carried down by gravity against the plunger or "starter" which starts them onto the tap. There are four of these feed vanes which are enclosed in a case in the center of the hopper to prevent interference from the mass of blank nuts in the hopper. The vanes are rotated through a ratchet and pawl mechanism. The ratchet is held between friction flanges so that in case there is any wedging in the nut groove and retardation of the feed vanes, the ratchet merely slips and damage to the mechanism is avoided.

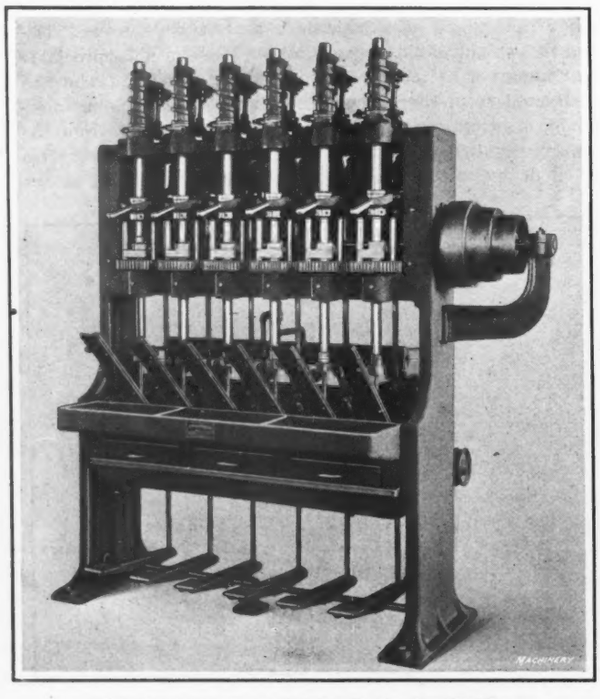


Fig. 24. Acme Semi-automatic Nut-tapping Machine

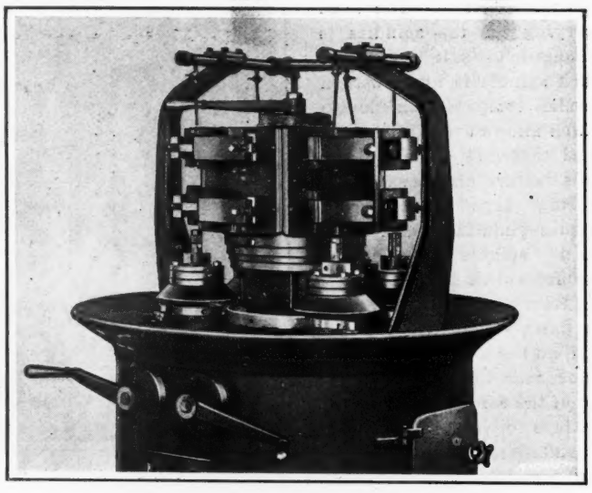


Fig. 25. Baush Station-type Tapping Machine

The tap spindle is inclined at an angle as shown in Fig. 22. The starter which transfers the blank nuts from the lower end of the chute to the tap is also inclined. The nut blanks leave the end of the chute at a corresponding angle so that they are in the proper position for starting on the tap. The tap spindle has a slight lateral travel or the equivalent of a floating movement. After a blank has been fed part way onto the tap by the starter, the spindle descends during the completion of the tapping operation. With this arrangement the blank is held stationary while being tapped instead of pulling it through a nut-holder or guides. This machine was designed primarily for tapping square nuts although hexagon nut blanks of good quality can also be tapped with it. One of these machines may also be arranged for tapping several different sizes and by making a simple gear change the number of nuts tapped per minute can be regulated to suit the work. For instance, on a 3/8-inch machine forty nuts of "shop" size can be tapped per minute if the stock is free cutting, the holes of the proper size, etc. U. S. standard nuts, which are thicker, require more turns of the tap for each nut, so that the production would be reduced to thirty nuts per minute. A similar reduction would have to be made if the nut blanks were of tough stock or the holes smaller than they should be. This type of machine is manufactured by the National Machinery Co., Tiffin, Ohio.

Station-type Tapping Machine

A special design of tapping machine intended for tapping the receivers and bolts of military rifles is shown in Fig. 25. The work-holding fixtures are mounted on the six faces of a central turret, and surrounding this turret are five tapping spindles. This leaves one blank position which is located at the front of the machine for the purpose of removing the finished product and replacing new blanks. The taps work progressively for tapping the holes to the required depth. The five spindles carry pinions which mesh with a common central driving gear. At the lower end of the central gear

shaft there is a combination clutch and bevel gear type of reversing mechanism by means of which the forward and reverse motions for the tapping spindles are obtained. The reversing clutch operates automatically. The rate at which the taps are fed to or withdrawn from the work is governed by independent lead-screws of the proper pitch. The indexing movement of the turret is effected by the hand-lever seen above the turret. When this lever is moved to the right it withdraws a locking bolt and allows the turret to drop onto a ball bearing track over which it is suspended. The same lever is then moved in the opposite direction to advance the work to the next station, after which the locking bolt springs into place. A slight additional movement of the index lever then lifts the turret off the roller bearing track and its upper face comes into contact with the finished face of an aligning block. The fixtures attached to the turret are designed in accordance with the part being tapped. The usefulness of the machine is not confined to the tapping of rifle parts, as it may also be applied to other classes of work. This machine is made by the Baush Machine Tool Co., Springfield, Mass.

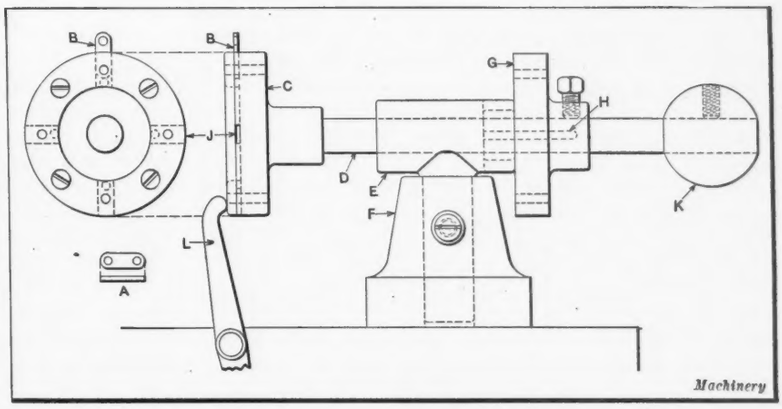


Fig. 27. Design of Fixture which, with Modification, has been extensively used for holding Small Parts while tapping

Work-holding Fixtures for Tapping

Parts to be tapped may be held in position during the tapping operation either by their own weight or by some kind of special fixture in the case of comparatively light parts. A simple and effective method of holding pieces on the table of a drilling machine, provided the work is light enough to center itself with the tap, is illustrated by diagram *A*, Fig. 26. Two parallel strips *a* are bolted to the table of the machine far enough apart to allow whatever piece *b* is to be tapped to slide freely into position. These parallel strips simply prevent the work from rotating when the tap is entering or backing out of the hole. Fig. 1 illustrates the use of long parallel strips for holding rectangular blocks while tapping holes in the ends. If the work does not have parallel sides, an auxiliary plate may be used to hold it. This plate may simply have a pocket or depression shaped to receive the work. In any case, the arrangement should be such that the part may be inserted and removed as rapidly as possible. By having the parallel strips under-cut to form a T-slot as shown, the screwing action of the tap cannot lift the work away from the machine table. Parts to be tapped in this way are first drilled and then tapped instead of performing the drilling and tapping operations without rehandling the work, as is frequently done when tapping pieces that are clamped to the machine table or are too heavy to center themselves when the tap enters the drill hole.

When tapping nuts, small blocks, etc., on a drilling machine, instead of placing one untapped blank at a time between the parallels, there may be an advantage in having a row of parts which is advanced for tapping each successive part, whenever an untapped blank is inserted at the feeding end of the parallels. With this method, the untapped pieces are pushed in between the parallels at one end and the tapped pieces are ejected at the other. These parallels, with whatever modification may be necessary, are often convenient for holding rods, etc., while tapping holes that extend crosswise through the work. The sketch at *B*, Fig. 26, illustrates how an auxiliary plate *c* may be used for holding a cylindrical part *d* when tapping a hole in the end. The work is clamped against the V-shaped side of the plate opening by a set-screw.

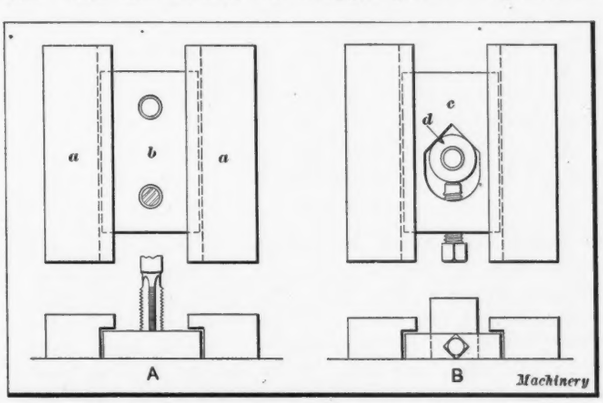


Fig. 26. Simple Methods of holding Work while tapping

The special tapping fixtures sometimes used on tapping machines for holding duplicate parts are, as a general rule, so designed that the work is held by some form of pocket or arrangement of stops so that clamping is unnecessary. It is also important to so construct the fixture that the tap cannot lift or draw the work out of place during the tapping operation. The tapping fixture illustrated in Fig. 27 embodies these fundamental points, and the general features of this construction are found in many fixtures of the class used for holding small duplicate parts which are tapped in large quantities. The small sheet metal part held in this particular fixture is shown at *A*. The fixture is provided with slots or pockets for holding the work in position as indicated at *B*. The flange-shaped member *C*, in which the work-holding slots are formed, is mounted on the end of a spindle *D* which is free to slide through the bearing *E* attached to the stand *F*. The shape of the slot for receiving the untapped blanks may, of course, be varied according to the shape of the work. In this particular instance, plain radial slots serve the purpose. Bearing *E* may be adjusted vertically in stand *F* to align the tap clearance hole of whatever fixture *C* may be carried by spindle *D* with the tap of the machine. Fastened to spindle *D* there is an index plate *G* provided with holes spaced to correspond with the work-holding slots in part *C*. These index holes are engaged by a pin *H*, which is fixed to the rear side of bearing *E*. When this fixture is in use, the operator with his left hand inserts an untapped blank as each slot arrives at position *J*; the spindle *D* is pushed forward or withdrawn by the right hand, which grasps knob *K*. When applied to one design of tapping machine, the spindle of the fixture is pushed forward until the hole has been tapped and engagement with lever *L* causes a reversal of motion; spindle *D* is then forced backward by the action of the tap, and as soon as the tap is withdrawn from part *C*, the latter is turned one-quarter revolution as determined by the engagement of pin *H* with a hole in plate *G*. This indexing movement locates the blank, previously inserted at *J*, in the tapping position. By means of a foot-treadle, the tap is again reversed so that it rotates in a forward direction and then the cycle of movements is repeated. As the tapped parts are indexed around they fall out of the fixture by gravity. The index pin *H* is of such a length that it will not release plate *G* until the tap clears the end of the fixture. A great many tapping fixtures for small work have been designed on this general principle, the details being modified more or less according to the requirements in each case.

Speeds for Tapping

The speeds for tapping vary between 15 and 30 feet per minute, according to common practice, these figures represent-

ing the surface or peripheral speed of the tap. When tapping cast iron, drop-forgings, or tough alloy steels, a surface speed of about 18 or 20 feet per minute is common. For tapping the softer grades of steel, such as Bessemer, open-hearth, screw stock, etc., the speed is generally increased to 20 or 25 feet per minute and may be higher under favorable conditions. In the case of tool steel, the speed may be reduced to 10 or 12 feet per minute. Speeds for tapping brass are, as a rule, several times as fast as speeds for cast iron or steel, there being a wide variation owing to the difference in the composition of alloys designated as brass. While taps are frequently operated at approximately the same speed as dies, the speed is usually somewhat less for tapping, partly because taps, as a class, do not discharge chips as readily as dies nor cut as freely; moreover, cooling compounds or oil may, as a rule, be applied more effectually to dies than to taps. In most shops where tapping is done, the speeds in feet per minute are not known. In many of these shops, it has been demonstrated by actual practice—which may in some cases extend over a long period—that if the driving belt of the machine is on a certain step of the cone pulley, or the speed controlling levers are set in a certain position, the tap will be driven at the proper speed. There is no particular reason why the speed in feet per minute, or even revolutions per minute, should be determined, which suggests an important point regarding all speed and feed data, namely, that at best they are only guides, and that the correct speed for a given tap, material, and other conditions affecting the speed, should, in each case, be determined by actual tests.

* * *

INDUSTRIAL ASSOCIATION OF CLEVELAND

A society known as the "Industrial Association of Cleveland" has been formed, the object of which is to create better understanding between employers and employes. The chief classes of membership in the society are employers and salaried employes, the general affairs of the association being in the charge of a governing board composed of twenty-five employers and twenty-five employes. The routine business of the association is conducted by an executive committee consisting of seven members elected by the governing board. It is worthy of note that in the election of members of the governing board, only employer members can vote for employer representatives and only salaried employes can vote for salaried employe representatives on the board.

The purpose of the association, as stated in a leaflet issued by the approval of the executive committee, is to educate, enthuse and energize, to make men more efficient and to harmonize effort. In general, the object is to accomplish cooperation in the industry and to organize the men in industrial work in one efficient organization for economic and industrial betterment. The officers and executive committee are as follows: Charles Woodward, president; H. B. Bole, vice-president; Edward Hobday, counsel and secretary; Melvin Pattison, treasurer; James H. Foster, C. E. Thompson, Willard Fuller, and W. H. Watkins, members.

* * *

Statements have been made in the press to the effect that there were prospects that the government would commandeer machine tools and machinery. This belief apparently has been due to the fact that some manufacturers of machine tools have been asking customers to state the purposes for which machine tools and machinery ordered by them were intended. This has been taken to be an indication that the government will assume control of the machine tool and machinery situation. However, this idea is due to a misconception. Machine tools that are to be used on government orders for the manufacture of war materials are given priority by request of the Ordnance Department; hence orders that are not intended for the manufacture of war material will have to wait until those orders that are directly connected with the prosecution of the war are completed. There does not seem to be any other foundation for the belief that the government intends to control the machine tool industry unless some unexpected developments should make it necessary.

WAR-TIME ECONOMY

BY J. S. M.

General Sherman said something when he uttered that famous definition of war; yet, while we in the mechanical field are making every effort to meet the demands of the times, and everyone is prating about war-time economy, there seems to be, through lack of efficient management or cooperation, much wasted effort.

Many of the young men of the profession have volunteered; many have been taken in the selective draft. Good, capable, dependable men are not nearly so numerous as a year or so ago, and some of the engineering offices look lonesome. Yet, in many cases, due recognizance of this fact is not apparent. For instance, corporation A, under government direction, sends out drawngs for estimates on cost, time, etc., to corporations or companies B to Z, yea, more than the characters of the Chinese alphabet. Each one of these must carefully estimate the weight of all the intricate details entering into the design; whereas, if corporation A had done this work and stated the weights clearly on the drawings, it would not have been necessary for a hundred or more concerns to take up the time of their depleted forces going over the same ground. This is a sample of war-time economy.

Again, a lot of machinery of various kinds is needed, and perhaps the concerns who manufacture these machines are so loaded up with work that they cannot turn them out in the desired time. What are they loaded up with? Often work out of their line and for which they are not properly equipped. They are going along without jigs, fixtures, gages, etc., and doing the work in primitive fashion, or to equip themselves, are expending labor that should not be so spent when Sam Jones in the neighboring town has all the machinery for this very line but is devoting his energies to something for which he is probably not any better equipped.

Concern S is shy on designers and draftsmen but is taking orders for tools in a new line and will have to design them from the ground up, putting the design into the hands of men who are not familiar with the class of machinery at all. The tools are wanted in a hurry, yet the designer has to familiarize himself with an entirely new machine, while a dozen other concerns have been building this class of machines for years, have all the experience, designs, patterns, tools, jigs, etc. It seems to the writer that if concern T cannot build these machines on account of limited output, the government should say to T, "Lend drawings, patterns, jigs, even foremen if necessary, to S." Of course, S may swipe T's designs and go into the business later on; besides it may batter up T's jigs, etc. Well, what of it? Cannot a written agreement be entered into which will protect T? Or perhaps S suffers from false pride and does not wish to build from T's designs, but blindly expends time to prepare new designs that are no better but are different. It seems as though such unpatriotic short-sightedness should be shown where to get off. There are by far too many concerns and men working their heads off at tasks they cannot perform economically, while the concerns and men who can do the trick with ease and rapidity are given some other task.

All sorts of strange things crop up. For instance, concern A controls B and owns outright C. A places an order with X, which sublets part to B, which, in turn, sends to C an order for castings that it sends to A for machining. B does some fitting and ships to X, which has sublet other parts that go through similar perigrinations, does part of the work in its own shop, assembles and ships it to A. A consigns to Y, which has sold to Z. Is this war-time economy?

* * *

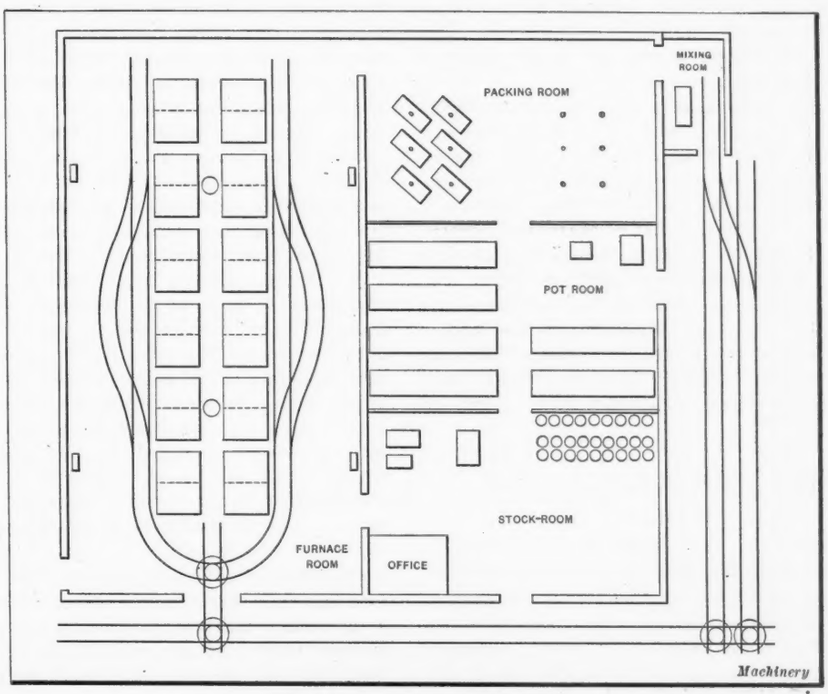
In recent experiments on Canadian railways, telephone messages were successfully sent from the dispatcher's office in Moncton to the moving train. The experiment was made on a double-track line where the rails were properly bonded for the block signal, the transmission to the car being made through the wheel and axle. It is claimed that as good results can be obtained on any track where the rails are similarly bonded, even if there is no block signal.

A WELL-ARRANGED CARBURIZING PLANT

BY C. B. LANGSTROTH [1]

From the ever-increasing use of alloy steels, one would believe that the process of carburizing low-carbon steel was on the wane. This may be the case with many concerns, but the Barnes Mfg. Co., of Indianapolis, Ind., still finds carburizing profitable, and the New England branch of this company has one of the most up-to-date plants for this class of work that is to be found. This plant has so simplified the process of carburizing and has brought the cost so low that it has completely done away with most of the objections to this method of treating steel.

When designing the buildings for this plant, the aim was to have the work progress from beginning to end without unnecessary handling, to perform the required work as cheaply as possible, and to have the working conditions of the employes as clean and comfortable as the work would permit. The modifying factor was that the primary cost must not be excessive. The buildings adopted were of standard mill construction, steel, with brick walls and concrete floors, 54 feet wide by 100 feet long. As shown in the accompanying illustration, two of these buildings are placed side by side and have one side wall in common. One building has a lantern type roof and contains the furnaces, while the other has a flat roof and is used for storage, packing, pot room, etc.



Plan of Well-arranged Carburizing Plant

The furnaces are oil-burning, of the over-fired twin-chamber type. They are entirely encased in steel plates and are securely tied together with steel binding rods. The walls and arches are built of the best quality firebrick and there is a double layer of insulating brick outside. The furnaces are arranged in two rows down the center of the room, with a four-foot walk between the rows. Under this walk is an opening, which contains all the oil, air, water and pyrometer pipes and other accessories. This opening is covered with steel latticework that is easily removed, thus making it accessible at any point. A two-foot space between each pair of furnaces allows the attendant to pass between the furnaces to adjust the valves. Over the burned-gas ports and the shelf in front of the furnaces is a steel hood, which is connected to one of the two unlined steel stacks; these hoods and stacks carry off the spent gases, heat and dust from the furnaces. The hood in front of the furnaces over the shelf, or lattice-iron grate, on which the carburized parts are dumped before being raked into the quenching bath, takes away the greater part of the smoke and dust due to this operation. All the work is quenched as quickly as possible after dumping, in order to avoid slow cooling, as this is one of the causes of exfoliation.

In front of the furnaces is a track sunk level with the floor, upon which are run the tanks for the quenching bath of water or oil and the cars for the used compound. The compound cars fit directly under the grates where the pots are dumped, so that the used compound falls directly into them. Both the quenching tanks and the cars for old compound are fitted with roller bearings, so that they may be easily moved by one man. A switch on each side of the room permits the cars to pass one another.

In discharging a furnace, only two men are needed, although in summer it is the practice to employ four men working in pairs. One man takes the pots out of the furnace, dumps them, and places the empty pots on a steel buggy. For this purpose he uses the regular U-shaped fork, which is suspended from an overhead track and works on ball-bearing rollers, so that it is easily handled. The second man knocks the cover off the pots and rakes the carburized parts from the grate into the quenching bath. After the quenched parts have cooled, the outlet and inlet of the quenching-medium pipes are disconnected and the car is pushed to the end of the room. Here an overhead motor-driven hoist lifts the basket containing the work out of the tank and carries the work to the tumbling barrels, where the work is cleaned. Before leaving the department, a part of each heat is tested by a representative of the inspection department.

The other building, used for the packing and storage, is divided into approximately three equal sections. The first section has large reservoirs below the floor for the fuel and the quenching oils. The reservoir for the quenching oil contains coils of pipes by which the oil may be cooled or heated; a secondary system of cooling coils, located on the roof, is put into service during the summer months. The quenching oil is thus always kept below 100 degrees F. The pumps for keeping both the quenching and the fuel oils in circulation are on the main floor. The remainder of the space is taken up as a storage room for the parts to be carburized. A small overhead electric crane facilitates the storage and handling of the barrels of work.

In the middle division, or pot room, all the various sizes of pots are stored. The pots, after being dumped, are carried by the steel buggies and left near the outside door of this room; when cool they are taken inside and stored in the section allotted to their particular size. Pots that are warped are laid to one side until a sufficient number have accumulated for it to be worth while starting the furnace in which they are heated for the straightening machine. This machine is simply a press that pushes the red-hot pots down over a form, and at the end of the down stroke pushes the four sides against the form. Besides the pots, all the spare castings, forks and other parts for the department are stored in this room. A visible record is kept of the supplies used by each furnace man.

The rest of the building is given over to the packing. The compound is stored in steel bins overhead and is brought down to the packers by chutes provided with the necessary shut-offs; there are two chutes for each packer. The absence of all benches, pots, and the like makes it easy to keep the room clean, which is quite the opposite from most packing rooms. Adjoining the packing room is a building in which the compound is sifted, weighed and mixed. The cars carrying the used compound are left outside this building until the com-

[1] Metallurgist, Colonnade Apartments, Indianapolis, Ind.

pound is cool, when it is removed to the sifter, where all the clay, scale and foreign substances are removed. Then the old compound is weighed and placed in the mixer with the proper proportion of new compound. The blended compound is taken from the mixer to the overhead storage bins by a conveyor.

In routing the material through the carburizing department, the orders are sent to the stock-room, where the quantity of work for one furnace is weighed out and placed on the shelf of a truck and the routing card is placed in a convenient steel pocket on the truck. These steel trucks are about thirty inches in height and of sufficient size to carry the pots for one furnace side by side. The truck is then taken into the pot room, where the required number of pots of the proper size are placed on it. The trucks are then sent to the packing room and placed under the proper compound chute. As the packer has the pots, work and compound all ready for assembling and everything is at hand, the work is accomplished in an amazingly short time. As soon as one truckload is finished, the packer has only to turn around to begin work on a truckload that is waiting to be assembled under the other chute. When the packing is completed the truck is taken to the furnace room, where the pots are luted. As soon as the proper furnace is empty, the pots are charged into it and the truck is returned to the stock-room, where any excess work is weighed and returned to the stores.

For the control of the temperatures, four multiple recording instruments are used; these are located on the side aisles, half way between the ends of the room and the center. The attendant obtains the temperature for the work from the routing card, which is carried by the truck with the packed work, and puts down on the card the time that he charges and draws. By this means the company has a complete record, along with the pyrometer chart, of the work the entire time that it is in the furnace. Most of the work receives only one quenching after carburizing, but where it is desired to give the work a second treatment the parts are placed on a number of large pans and charged into the furnace. This method has been found the most convenient for handling a large output of small parts.

* * *

LIMITATIONS AND WARRANTIES

BY CHESLA C. SHERLOCK [1]

Manufacturers, wholesalers and jobbers do business every day that involves the law of warranties in some form or other. One of the closest questions under this subject is the proposition of when the statute of limitations commences to run in case of breach of warranty on the sale of chattels. Generally speaking, the statute of limitations provides that one having a cause of action must bring it before the courts within a specified time or any claim that he might have arising thereunder will be forever barred. Suppose, for instance, a jobber of machinery purchases some defective engines, which a little later he sells to a retail dealer, who, in turn, sells them to the "ultimate consumer." The time required to move the engines from the manufacturer to the consumer, though, has been long enough to get beyond the local statute of limitations. As soon as the purchaser attempts to use the engines, he finds that they are of faulty construction and are not as represented, and so turns to the retail dealer, who, in turn, looks to the wholesaler. The wholesale dealer finds a lot of defective engines thrust back upon him and stands to lose a large sum of money unless he can compel the manufacturer to make good his warranty on the goods. The questions very naturally arise: Did the statute of limitations commence to run at the time of the original transaction or sale between the manufacturer and the jobber? or, did it commence to run as soon as the defective condition of the machinery was discovered by the purchaser? It is needless to say that if the answer to the first question is in the affirmative, that the wholesaler or jobber will be made the victim of the circumstances and will be unable to cover his losses; if the second question is answered in the affirmative, the primary liability in warranty cases must forever rest upon the manufacturer.

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The courts have very pointedly held that the statute of limitations does not commence to run until the breach of warranty has been discovered, or should have been discovered, by the retailers. The particular case under consideration by the courts was where the sale of canned goods to a wholesale grocery house was being brought up on a breach of warranty. The court said that this proposition, so far as it related to canned goods, should hold where it was not practicable for the wholesaler to open the cans for inspection. It might be said in passing that this ruling will hold true in the case of other chattels where it is not practicable for the wholesaler to make thorough tests of the particular goods he might be handling.

Much depends on the nature of the warranty as to whether or not it is present or prospective. The courts have disagreed over this proposition. Some have held that the warranty is present and broken as soon as made and that the statute of limitations commences to run at once; others have held that the warranty is prospective, as relating to some future event, and is not broken until the happening of that event. If a warranty as to the quality of an article is assumed to be present, the general rule is that the breach occurs as soon as made and the statute of limitations will commence to run at once. This rule is predicated upon the theory of law that ignorance of the fact that one has a cause of action, apart from mistake, trust relations, fraud or laches, does not prevent the statute of limitations from commencing to run. It is self-evident under these cases that the statute of limitations commences to run before there is an opportunity for the aggrieved party to discover that fraud has been done. And it is very probable that the entire time under the statute of limitations might run before there was even a reasonable opportunity offered for the injured party to discover the deceit.

The earlier decisions in the law of warranties were overwhelmingly in favor of the proposition that the breach was a present one and the statute of limitations would commence to run at once. The later cases, especially in recent years, have been leaning, as nearly as it is consistent for courts to do so, toward the proposition that they are prospective and do not take place until some future time and upon the happening of an event at such time. Probably the first case that turned the attention of the bench to the fact that it was not equitable to hold the breach of warranty as a present one was where a farmer purchased a high-grade bull that had been warranted as a breeder. He had had no opportunity to try out the warranty thoroughly until after the statute of limitations had run. The representation had been made on the sale of the animal that upon satisfactory proof of barrenness, the purchase money less the value of the beef would be refunded. The court said that the statute did not commence to run until such proof had been made. Since that time there has been an ever-increasing gap between the line of decisions as to when statutes of limitation commence to run.

The rule in such cases may be summed up as follows: Where the defect is apparent or readily ascertainable by the immediate purchaser, the breach is present and the statute of limitations commences to run as soon as the warranty is made; where there is no means of the immediate purchaser examining the goods or testing the warranty as made, and where such an examination cannot be made except upon the happening of some future event, as a resale to one in a position to make the test, then the warranty is prospective and the statute of limitations does not commence to run until the breach of warranty is discovered.

* * *

At this time, when the cost of writing ink has increased fully 100 per cent, some readers of MACHINERY may be interested in the fact that very satisfactory ink can be made from worn-out copying typewriter ribbons. The stores department of the M. K. & T. Ry. has called the attention of its departments to the possibility of making this ink as follows: Fill a quart bottle with water and allow the ribbon to soak twenty-four hours until the coloring matter has been dissolved. The result will be a good grade of writing ink—as good as can be purchased on the market. It may be used in fountain pens.

SCREW MACHINE TOOL EQUIPMENT—2[1]

TOOL EQUIPMENT AND ATTACHMENTS FOR THE GRIDLEY MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINE

BY DOUGLAS T. HAMILTON[2]

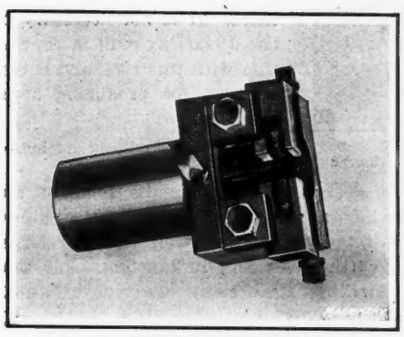


Fig. 16. End-working Knurl-holder for Gridley Automatic

IN the preceding installment, published in the October number, the standard holders were illustrated and described; these holders serve to carry various types of end-working tools, such as drills, reamers, counterbores, etc. The bushings used in connection with them are made to conform to the shape of the tool used. When straight-shank drills are used, a plain bushing is all that is necessary; these were shown in Table 3 in the October number. But when the drill is of the taper-shank type having a tang, it is necessary to use a special bushing. Boring-tool holders generally consist of a plain split bushing, which can be clamped on the shank of the tool.

End-working Knurl-holder

The type of end-working knurl-holder used on the Gridley automatic is shown in Figs. 16 and 17. This holder is provided with a shank, which is gripped in a standard holder. The knurls are held in slides, which may be adjusted by collar-head screws, Fig. 16; the slides fit in grooves in the holder proper and are held by clamping blocks when adjusted to the desired position. This type of knurl-holder can be used only when it is possible to advance it longitudinally with the work, and it cannot be used for knurling behind shoulders. When knurling behind a shoulder is necessary, a holder must be fitted up on either of the forming slides, preferably the front.

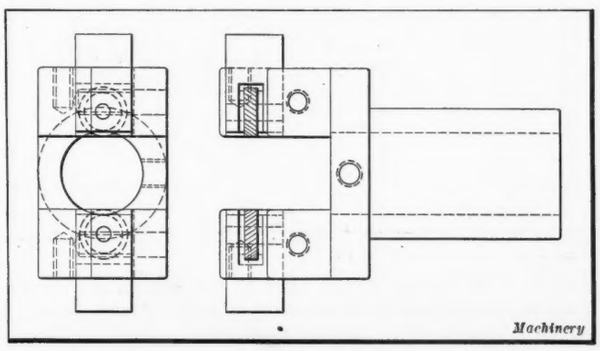


Fig. 17. Detail View of End-working Knurl-holder shown in Fig. 16

Under-cutting Tool-holder

Fig. 18 shows what is known as an under-cutting tool; this is attached to the tool-slide by bolts and T-nuts. It presents the turning tool radially to the work, instead of tangent to it, as is the case with the regular turners. This type of tool can be used to better advantage for facing and light cuts than the tangent cutter, and is adjustable for height; the entire holder is adjustable for position along the tool-slide in the regular manner.

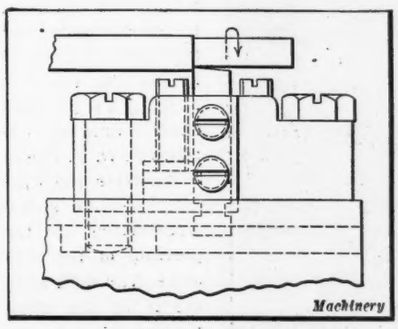


Fig. 18. Under-cutting Tool-holder for Use on Tool-slide

[1] The first installment of this article was published in the October number.

[2] Address: 45 Woolson Ave., Springfield, Vt.

Internal Recessing Tool-holders

When it is necessary to enlarge a hole back from the front end of the bar, a recessing tool must be used. Fig. 19 shows a tool-holder used on the tool-slide for recessing purposes. This holder depends for its traverse movement on a bracket attached to the forming slide of the double-tool type. The top part of the forming slide is provided with two tapped holes in which screws are inserted for holding the bracket. The bracket carries an adjusting screw, which comes in contact with the movable slide of the recessing tool when the forming slide is advanced. The adjustable slide that carries the cutting tool is forced forward against the tension of a spring, which returns it to its normal position as soon as the pressure is removed. In order to use this internal recessing tool, it is necessary to furnish a special cam for the forming slide, so that the slide can be brought up to the desired position, and then made to dwell there while the necking tool is advanced longitudinally with the work. The depth of cut is controlled by the advance of the forming slide, which forces the tool into the work. When the operation has been completed, the forming slide is withdrawn and the tool-slide moves the recessing tool away from the work. This tool can be used in the second or third position.

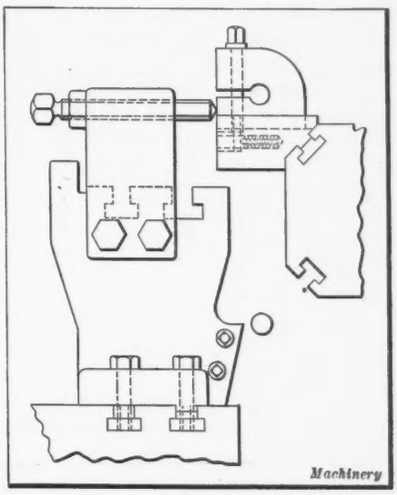


Fig. 19. Internal Recessing Tool-holder for Use in Second Position

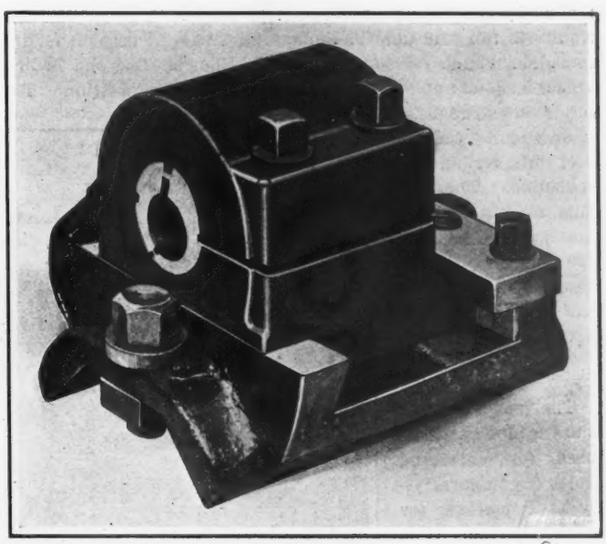


Fig. 20. Internal Recessing Tool-holder for Use in Second and Third Positions

Another type of recessing tool is shown in Fig. 20; this is adapted for use in the second and third positions. The tool-

holder is attached to the tool-slide, and is additionally supported and controlled when in operation on the work by the slide that ordinarily carries the die-spindle bracket. The movable member of the holder carries two cutting tools of the circular type, which are sharpened like a regular circular forming tool.

Careful inspection of this special tool will show that it is provided with two slides. The lower slide is attached to the tool-slide, and consequently moves with it, whereas the top slide is attached to the top bracket that connects the two ends of the machine. The tool-holder must have two movements; one to advance the tools into the work to the required depth, relative to the end of the work or the face of the spindles, and the other to produce the required depth of cut. The movement for position is controlled by the forward movement of the tool-slide in conjunction with the stud held in the special Y-shaped bracket on the tool-slide, which carries the stop-rod shown; this rod is provided with a nut which can be adjusted for position. The other movement is controlled by the special bracket on the tool-slide. The cutting tool in the second position is used for roughing the recess, while that in the third position is used for finishing.

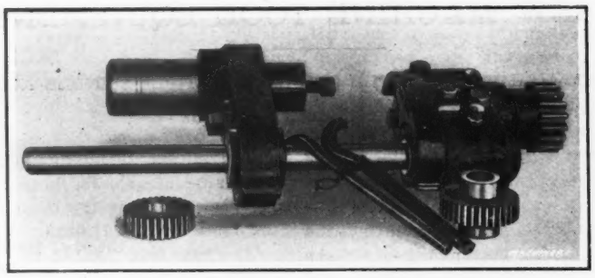


Fig. 21. High-speed Drilling Attachment for Use in First and Second Positions on ¾- and 1¼-inch Machines

Set-over Tool-holder

The tool-holder shown in Fig. 24 is used for enlarging holes of comparatively little depth or for counterboring. It is also sometimes used in the place of a drill for holes that are not more than 1½ times their diameter in depth. The cutting tool works and acts the same as a forming tool, but instead of cutting on the outside surface of the bar, it cuts on the end. The tool-holder has a set-over adjustment, so that the same cutting tool can be used for machining various diameters of holes. It is not necessary to use a starting drill in connection with this tool, and it can be used for producing accurate work.

High-speed Drilling Attachments

Although the tools of the Gridley automatic are held rigidly to the tool-slide, it is necessary in some cases to rotate the drill as well as the work in order to increase the cutting efficiency of the tool. For this purpose a high-speed drilling attachment, one type of which is shown in Fig. 21, is used. This attachment is of the universal type and can be used in either the first or second positions on the ¾- and 1¼-inch machines.

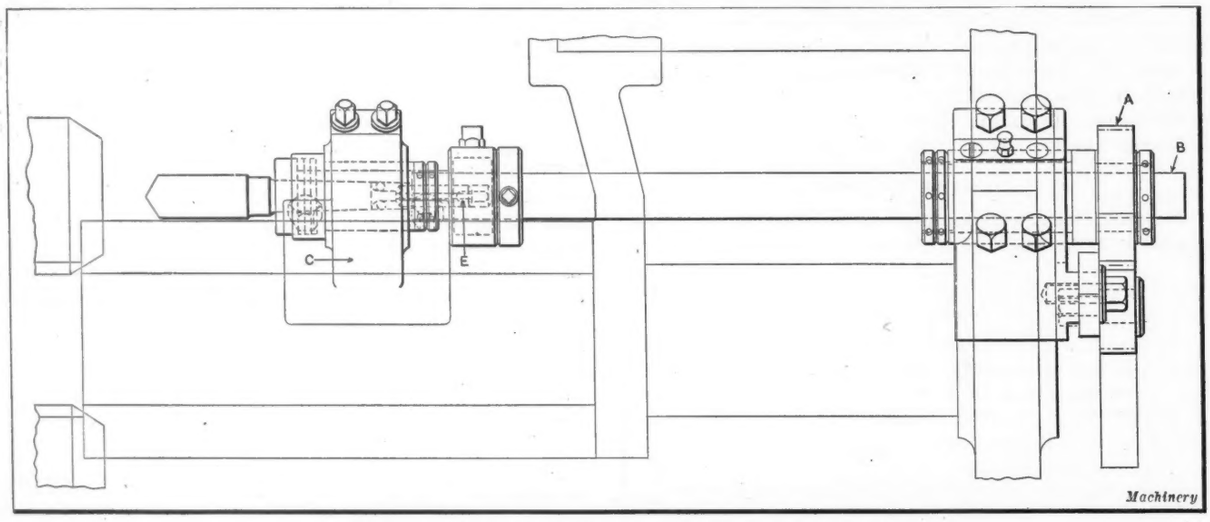


Fig. 22. Detail View of High-speed Drilling Attachment shown in Fig. 23

Fig. 27 shows a sectional view of the attachment, which, when in use, is held on the main upright frame of the machine and is driven from the spindle gear through a gear *A* carried on a shaft *B*. Gear *C* on shaft *B* meshes with a gear *D* on the main drive shaft *E*, which has a spline its entire length and carries a sliding gear *F* which is keyed to it. This gear *F*, through an idler gear *G*, drives the gear *H* that is carried on the drill spindle. Gears *F*, *G* and *H* are enclosed in a case, which is formed into a bracket attached to the tool-slide. As this forward member moves with the tool-slide, the splined shaft permits the gears *C*, *D*, *F*, *G* and *H* to drive the drill at a positive speed, irrespective of the position of the tool-slide. The drill spindle is of the collet type and is operated from the rear end by

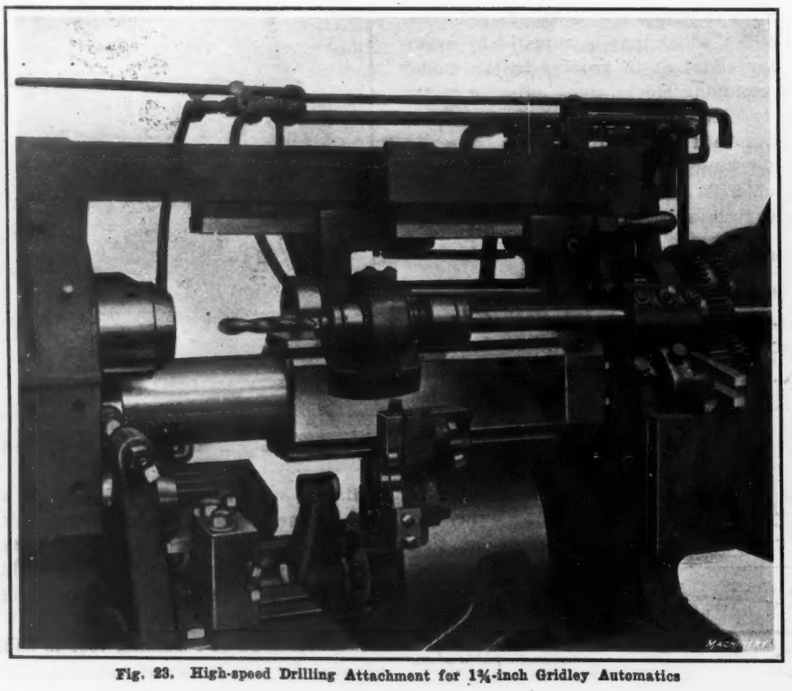


Fig. 23. High-speed Drilling Attachment for 1¼-inch Gridley Automatics

means of a nut. It is also provided with a split bushing of the required size to fit the shank of the drill. With this arrangement of gearing it is possible to increase the speed of the drill greatly, and therefore operate a small drill at its proper cutting speed.

Figs. 22 and 23 show the high-speed drilling attachment for use on the 1¾-inch Gridley automatic; this particular attachment can be used only in the second position. It is driven in the same manner as the one just described, with the exception that the set-off arrangement makes the drive direct, and consequently no idler gears are necessary. In order to get the correct speed for certain size drills, it is necessary to use an idler or intermediate gear at the source of power, as shown in Fig. 23. This gear is held on an adjustable arm, and can be swung into contact with the gear on the pulley spindle. The drive, as shown in Fig. 22, is then direct through gear *A* on shaft *B* to the drill. Spindle *B* is supported in a bracket on the frame of the machine. This bracket is so placed that the spindle *B* is made to line up directly with the tool-holder *C* which is clamped to the face of the tool-slide. Adjusting collars are held on the main spindle to provide for wear due to end thrust.

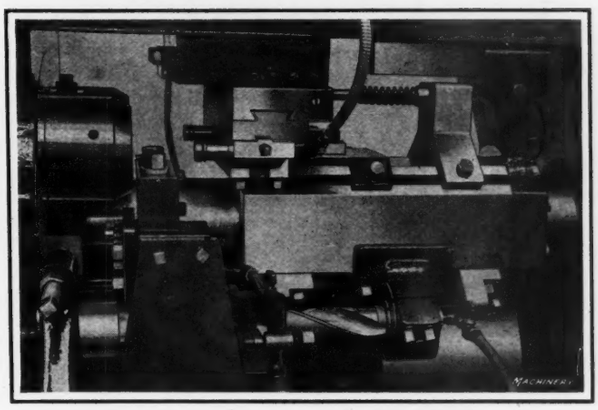


Fig. 24. Set-over Type of Tool-holder

The drill spindle is arranged to carry taper-shank drills, and is provided with a drift slot for removing them; this is covered by a collar, which is held in place by a lock-nut. To remove the drill, the headless screw in the lock-nut is released, and the collar pulled back, exposing the drift slot; the drill can then be removed in the usual manner, a plug *E* serving to force it out of the socket.

Die-spindle and Die-holder

The die-spindle has been described in a previous article, where it was mentioned that the spindle was operated entirely independently of the movement of the tool-slide, and was driven by a separate spindle through gearing and a clutch mechanism. Fig. 26 shows a close view of the die mechanism with the die-spindle advanced to the position that it occupies when feeding on to the work, just before the clutch is disengaged. It will be noticed that the die-holder is a separate member held in the die-spindle, and that it is moved back and forth by a yoke that forms a part of the die-slide. The die-holder is free to rotate in this yoke, and end play is taken up by adjusting collars. The spring screw die which is being used in this case is held in the holder by means of a screw hidden by the knurled collar that protects it. A button die can also be used by substituting a holder designed for that purpose.

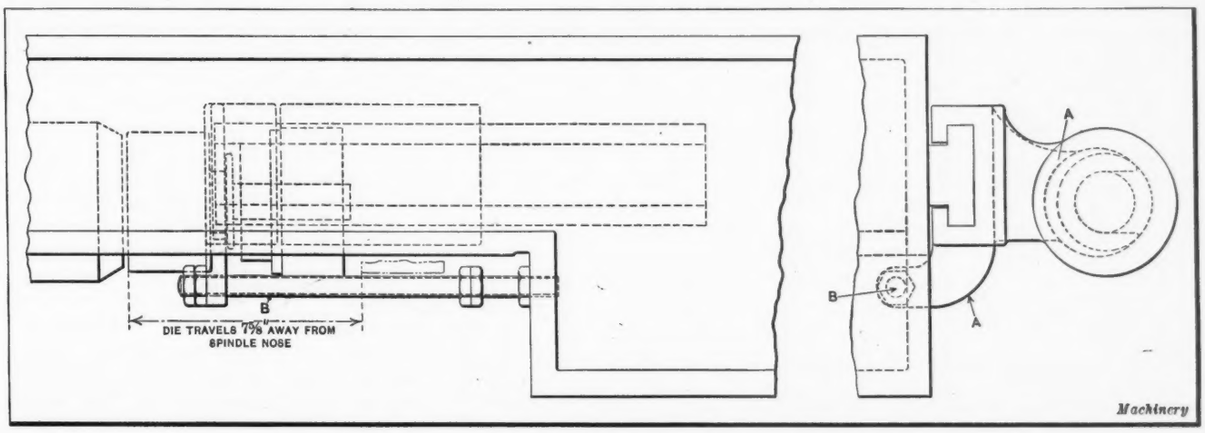


Fig. 25. Special Attachment for operating Automatic Dies on Gridley Automatics

When it is desired to use an automatic die on the Gridley automatic, a separate attachment, illustrated in Fig. 25, is necessary. The automatic die is held in the die-spindle by its shank, and is opened and closed by a forked arm *A*, which is made in the form of a slide and fits on the same member as the die-slide. The forked arm has an extension that is drilled to fit over the operating rod *B*. This rod is carried in a bracket attached to the tie-member that connects the two ends of the machine and also carries the die-slide. Adjustable lock-nuts are carried on rod *B*, which can be set to open and close the chasers at the desired point of travel of the die-head.

The first and second installments of this article on the tool equipment of the Gridley multiple-spindle automatic screw machine have covered forming and cutting-off tools and holders, turners,

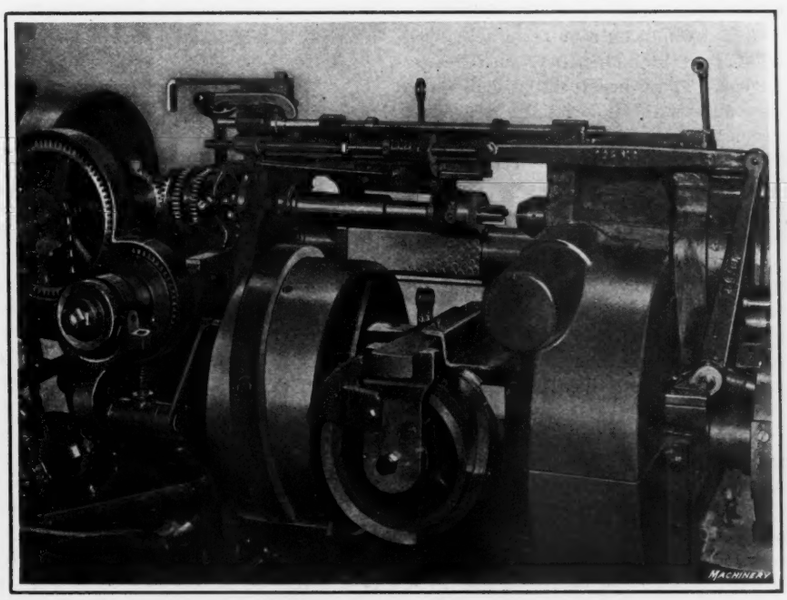


Fig. 26. Die-spindle and Die-operating Mechanism of Gridley Automatics

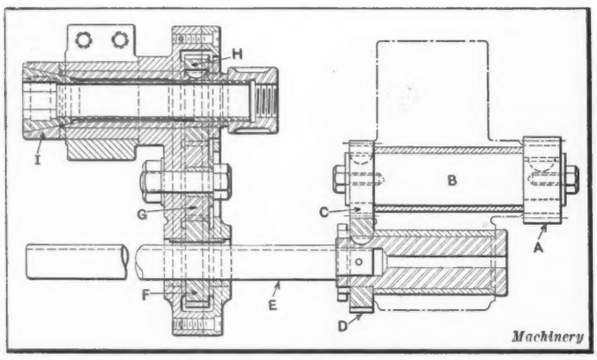


Fig. 27. Detail View of High-speed Drilling Attachment shown in Fig. 21

back-rests, tool-slide tool-holders, knurl-holders, recessing tools, drilling attachments, and die-holders. The next installment will deal with self-opening die-heads, spring screw threading dies, speeds for threading, reaming attachment, and taper-turning attachments.

* * *

HEAT-TREATED GEARING

BY W. H. PHILLIPS [1]

Steel gears may be divided as to material and structure into two general classes—alloy steels and carbon steels. Alloys of nickel, chrome-vanadium and similar elements with steel produce a strong, tough gear, which, however, because of its high cost, is practicable only for a few special uses. The great field of gearing is served by carbon steel products with entire satisfaction. Since it is possible by heat-treatment to increase the life of carbon steel gears by as much as 200 to 400 per cent, with a cost increase of but 25 to 50 per cent, these processes have received much attention. There are now three general classes of treatment; oil, casehardening, and a special treatment. The first two classes mentioned were introduced in the above sequence and have met many problems. Each has its advantage for different services and has proved very efficient. There are conditions encountered, however, in which these two grades are not applicable. The third grade mentioned has been developed after a careful study of actual conditions and embodies the best qualities found in both former grades.

There are applications where the service is so light that the resultant long life and low maintenance cost does not recommend a high-grade product. There are other services where the gear must transmit a uniformly high torque without sudden jars or dynamic blows, in which case it is a question of wear alone, requiring such surface hardness as is found in the casehardened product. There are other applications where the load to be transmitted is uniformly low but with occasional shocks. This last-named condition requires a gear with only medium hardness but with high ductility, such as the first class or oil-treated gear. There are installations where the service imposes heavy duty with its resultant wear, and shocks with the liability of breakage. It is for such service that the third class or special grades have been developed. By analyzing the conditions and selecting the proper grade, it will be possible to obtain the best results.

With the ever-increasing knowledge of steel and its heat-treatment being accumulated year by year, the first two grades were improved gradually until now they have been perfected as far as possible, and the metallurgist for some time has been looking to other fields for a grade that would include the good qualities of both the other grades and yet supply what they lacked and, if possible, reduce the cost of the heat-treatment. As stated before, the alloy steel had to be eliminated because of its cost, and the only course left was to develop a treatment for carbon steel that would give the required results. Several of these so-called special grades were introduced, one of the most notable being the BP grade manufactured by the R. D. Nuttall Co., Pittsburg, Pa.

It was found that by slight changes in chemical structure, a combination could be obtained, which when subjected to a special treatment would produce physical properties peculiarly adapted for gearing. The hardness at the surface of the steel is from three to four times that of untreated steel, and grades off slightly toward the center of the tooth until it is from two and one-half to three times as hard as untreated steel. This reduction in hardness is in a straight line ratio, and each fiber of the steel from the surface to the center, or neutral axis of the tooth, which may be slightly to one side of the geometric center, will be stressed in proportion to its ability to carry the load, so that, when the tooth receives a blow or shock, every fiber is carrying its share of the load. The ductility of this steel is comparatively high and is in inverse ratio to the strength. The metal is homogeneous, there being no line of demarcation between any two fibers. While the surface of the tooth is hard, it is of a tough hardness and will not check nor spall. It is often advisable to treat the pinion only of a combination, it being the weaker and harder worked member. A pinion so treated, due to the nature of the hardness, is not likely to cause excessive wear on the meshing untreated gear. It can be readily seen that a gear of this type, which is of moderate price, will have a great tendency to overcome breakage and at the same time give a high resistance to wear. It should at least triple the life of untreated gearing, and eliminate the cost of consequential damage and delays caused by gear breakage.

If by increasing the cost of gearing from 25 to 50 per cent a gear is produced that will more than triple the life of the untreated steel gear and at the same time eliminate breakage with its consequent damage, there can be no doubt of its economy. A few of the advantages to be derived by such a step are: lower ultimate cost of gearing; reduction of time loss; reduction of labor maintenance; and reliability. For example, the untreated gear costs twenty dollars and runs one year, while the treated gear costs thirty dollars and runs three years. This would show a saving of thirty dollars on initial cost. If it requires two hours to make replacement, it would require six hours to replace the untreated gear three times and but two hours to replace the treated gear; thus four hours is saved in labor, and four hours is saved in the production of the machine. The hazard of breakage with its consequences is an unknown factor, but it may be serious in some services.

The wide application of the heat-treated gear, not only in the railway and automobile field but also in many branches of the industrial field, among the more notable being the steel mills, foundries, glass plants and mines, has been so successful that it is not a question of heat-treated versus untreated gearing, but rather the selection of the proper grade of treated gear for the service to be performed. With many industries of the country working over capacity, the necessity for reliability of machine parts was never before so urgent or the consequences of breakdown so costly. A careful study of the gear situation in the plant or mine should be made, and any changes insuring this reliability acted upon at once.

[1] Research Engineer, R. D. Nuttall Co., Pittsburg, Pa.

* * *

UNITED STATES EXPORTS

Since the beginning of the European war, exports from the United States to the neutral world have doubled, and those to the belligerent world have trebled. In the government's fiscal year of 1917, the total exports to the neutral world were $2,252,000,000, as compared with $1,061,000,000 in 1914, and to belligerent Europe, $4,042,000,000, against $1,304,000,000 in 1914. The increase in exports to the non-European world was 110 per cent; to the entire neutral world, 112 per cent; and to the belligerent countries of Europe, 210 per cent. The chief gains in this exportation to the neutral countries outside of Europe occurred in the trade with Canada, Mexico, Cuba, Argentina, Brazil, Chile, China, Japan and India. These countries have increased their purchases from the United States largely by reason of the difficulty in obtaining merchandise from Europe. South America drew from Germany about $175,000,000 worth of imports in the year before the war; from Austria-Hungary, about $10,000,000; from Great Britain, approximately $250,000,000; and from France, approximately $75,000,000.

SNAPSHOTS ON THE ROAD

THE GENERAL MACHINE SHOP—STARTING THE NEW JOB RIGHT—GIVING A FELLOW A CHANCE—A FISHERMAN'S GUIDE—LAYING OUT A FOUR-PITCH THREAD—EFFICIENCY AND COOPERATION

BY THE FIELD EDITORS

THE days of the general machine shop, the kind that would repair anything made of metal, are certainly numbered, and to find a real example of this kind is a rarity. We discovered one of these shops recently in a Connecticut seacoast town, and the aged proprietor told us of his work about as follows:

"Yes, business is pretty good—great variety, great variety. Why, just yesterday a farmer drove in here to have his mowing machine repaired and ten minutes later in came an old Dutch musician to have the windpipe on his slide trombone soldered. Dutchy had been playing the night before at a charity ball and made several detours on his way home, leaning too heavily on his trombone. This just illustrates the class of work we get, and my chief difficulty is the fact that I can't get the right kind of men. I have one man who can handle a micrometer or a wheelbarrow with equal dexterity, but his kind are scarce."

"—a farmer drove in here to have his mowing machine repaired and . . . in came an old Dutch musician to have the wind-pipe on his slide trombone soldered"

We predict that this shop proprietor will find men of the last-mentioned type increasingly difficult to locate.

Starting the New Job Right

We often hear some good stories of the early days of men who have made good, and here's one from a successful superintendent whom, for the sake of brevity, we'll call Ed: Back in the shop where Ed served his apprenticeship he was considered a pretty good planer-hand, and because of this fact, he had worked on the planers in the old shop for a year after he finished his time. So naturally he wasn't worried when he applied for a planer-hand's job in the Dayton Ship & Engine Co.'s plant. "Yes, sir," he told the employment manager, "I've run planers for the best part of four years, and I'll take a job as a planer-hand if you have one." So Ed was hired and went down into the engine shop and was assigned to a machine. But when he saw that planer his heart nearly dropped two feet, because the planer they had assigned to him was twelve feet between the housings, with a table thirty feet long! The man who had run the machine for years and was considered the planer expert of the shop had met with an accident and was laid up with a broken leg, and no one else in the shop had had the courage to start that machine.

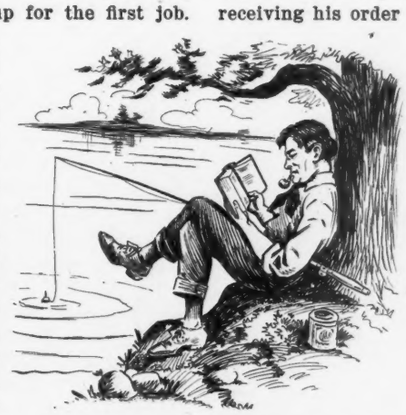
Ed was a pretty cool-headed young chap and one of those fellows who "never says die"; so without making any comment he started to set that big planer up for the first job. Meanwhile the other men of the shop were watching him out of the corners of their eyes to see what would happen. After a few hours of setting-up time, Ed had the big engine bed located, strapped down and ready for the first cut. He ground up the big tools and located them in the right positions in the heads ready to start. He knew the eyes of the shop were on him and he wasn't any too sure that things were right himself; nevertheless it wouldn't do for him to show the white feather at this time. So, when all was ready, he walked around the table to the starting box, and without paying any attention to the chaps who were stealing glances at him, he reached up with his foot and kicked the starting lever over carelessly, as though he had started a big planer so many times he was bored at the thought of doing it again. That little act was enough. As soon as the other chaps around the shop saw the careless way in which he started the machine, they made up their minds that he was master of the planer. Ed had the stuff to back up his confidence, because he did know planers, and he had no trouble in showing that shop he could fill the old planer-hand's shoes—not a little credit of which was due to the way he started.

Giving a Fellow a Chance

There are many factory clerical jobs that are filled by bright young fellows who have ambition to rise, but rising through the medium of factory clerical work is generally conceded to be difficult, if not impossible. A certain young clerk with a prosperous up-to-date factory, realizing the limitations of his position and noting a recent vacancy in running one of the large, complicated machines in the department, asked his foreman for an opportunity to be transferred from his work to the machine. The foreman laughed at the young fellow, the first thought coming to his mind being the difficulty of breaking a new man in on the clerical job, which this fellow could do to perfection. Because of his insistence, however, the foreman took the matter up with the superintendent, who is a man of some foresight. The superintendent said, "By all means, give the boy a chance. We can get somebody else for clerking, and why isn't that a logical way to secure coming young men for our organization?" This young man proved to be a star operator and his previously obtained knowledge of the systems in vogue in the shop soon made him one of the most valuable men in that department. He studies constantly, and if he doesn't contain the material for a future superintendent or manager, the present indications are misleading.

A Fisherman's Guide

MACHINERY'S HANDBOOK is generally conceded to be useful, ornamental and in every way helpful to the practical man. It covers almost every subject that pertains to modern mechanical work, but one of our readers apparently finds the chapters on "Cutting Herringbones" and "Fishtail Cutters" helpful on his fishing trips. We arrived at this conclusion after receiving his order last Thursday for a handbook which read as follows: "Enclosed please find $5 for a copy of MACHINERY'S HANDBOOK. Please send so that I will receive it before Sunday, as I am going fishing and want it." That is our deduction; what is yours?



"—finds the chapters on 'Cutting Herringbones' and 'Fishtail Cutters' helpful on his fishing trips"

Laying Out a Four-pitch Thread

Down at the old windlass plant, we dropped in to see our friend Jones, the superintendent. Jones is a philosophical sort of chap and he always sees the interesting things in life, the writing of which helps to make bread and butter for the man who has a nose for news. This time it was an interesting story with a moral that he had to tell.

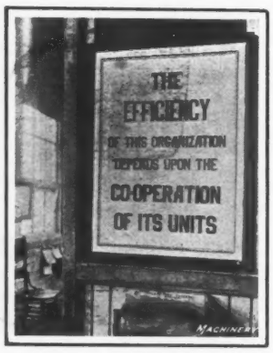
"A bright-looking young chap came into the office the other day and wanted a job.

To my questions as to what he could do, he assured me that he could do anything, and when a man tells me that, I'm always suspicious. I told him we had an opportunity for a lathe-hand on the night shift, and he promptly informed me that he was a good lathe-hand, so I started him in. His first job was to cut a big windlass screw with a four-pitch square thread. It afterward developed that this chap had never even seen a lathe before, let alone run one, or cut a thread. By some hook or crook he found out how to get his shaft on centers and how to put on the power, and as the man before him had left a tool in the lathe, his common sense helped him to find out how the feed handles operated. But cutting the thread was certainly some mystery to him! After much study of the drawing and measuring with calipers and scale, he decided to lay that thread out and get it right. So he carefully laid out the shaft, prick-punching every quarter inch for the entire length, after which he drew in the spiral around the circumference at each ¼-inch interval. His courage was fine, for he intended to chew that thread out by operating the cross and longitudinal feed handles by hand! But about the time he got fairly well into a cut, and had wobbled along a little way, I came up and looked over his shoulder. There was no time wasted in argument; we both understood. He reached for his coat and beat it."

"There was no time wasted in argument"—

Efficiency and Cooperation

A state of efficiency in an organization is certainly highly desirable, and attempts to arrive at this state have been made in many ways. Along these lines we recently noticed a framed motto in the factory of a successful New York manufacturer. It is in the form of a suggestion to be kept constantly before the employes and reads as follows: "The efficiency of this organization depends upon the cooperation of its units." This is mighty good logic, and there is hardly an organization in existence that could not apply this motto to its everyday transactions. The need of cooperation among departments is as great as among individual employes. The departments of many large concerns often consider that they have very little to do with the other departments, and the result is internal bickering rather than efficient co-working. The manager who can instill into the employes the principle of this motto is assured of a stable and efficient organization.



"It is in the form of a suggestion to be kept constantly before the employes—"

* * *

According to a recent bulletin issued by the Bureau of Mines, 100,000,000 gallons of gasoline was obtained from natural gas by the compression and condensation method. This gasoline can be blended with naphthas that otherwise are unsatisfactory for use in the automobile and made into an acceptable motor spirit. By the absorption process, which has been but recently perfected, the gasoline in natural gas, though extremely lean, can be absorbed in oil, from which it is separated by distillation. Natural gases yielding less than one pint of gasoline from each thousand cubic feet have been treated with commercial success, where formerly this gasoline had gone to waste and had constituted a source of much trouble and expense in the pipe lines.

PATENTS OWNED OR CONTROLLED BY AN ENEMY[1]

The Act of Congress, approved on October 6, known as the "Trading with the Enemy Act," gives the president the authority to grant licenses for the use of patents owned or controlled by an enemy, or ally of an enemy, provided he shall be of the opinion that such a grant is for the public welfare and that the applicant is able and intends to make use of the patent. This power and authority he has vested in the Federal Trade Commission.

Such a license will be a complete defense to any suit at law or in equity instituted by the owners of the patent against the licensee for infringement, or for damages, royalty or any money award on account of anything done by the licensee under such a license. The act provides that a license fee not exceeding $100 shall be charged, and not exceeding 1 per cent of the sum deposited with the alien property custodian. This sum is not to exceed 5 per cent of the gross sums received by the licensee from the use of the patent, or 5 per cent of the value of the use as established by the Federal Trade Commission, and is to be a trust fund for the licensee and for the owner of the patent, to be paid from the treasury of the United States upon order of the court in case the owner of the patent may, after the end of the war, file a bill in equity against the licensee in the District Court of the United States for recovery for the use of the patent, and the court may adjudge and decree to the owner payment of a reasonable royalty from this fund. If no suit is brought within one year after the end of the war, the licensee shall not be liable to make any further deposits, and all funds deposited by him shall be repaid. For this fund the licensee must file with the Federal Trade Commission semi-annually, and oftener if required, a full statement of the extent of the use of the licensee, and of the prices received from the sale for use of the patent. If suit is brought, the court may at any time terminate the license and may issue an injunction to restrain the licensee from infringement thereafter, or in case the licensee shall have made investment of capital based upon the possession of a license, the court may continue the license for such a period as it shall find to be just and reasonable.

Applicants for such a license are required to file a verified statement with the commission covering the following points:

1. If an individual, that he is a citizen of the United States, or if a corporation, that it is organized within the United States.
2. That the patent desired to be licensed is owned or controlled by an enemy or an ally of an enemy, and what the nature and origin of the control is.
3. There shall be attached to the application a Patent Office copy of the patent and a certified abstract of title to it, and a certified copy of the petition and all powers of attorney in the file of the application.
4. That there is a demand for the patented article or the product of the patented process which is not being met.
5. That the applicant is able to make the patented article or exercise the patented process. Specifically, that the applicant is technically and otherwise equipped to undertake or procure the manufacture or operate the process, and is in fact able to do so.
6. That the applicant intends to do so in good faith.
7. The application must be verified by the person applying for the license and in case of a corporation, by an officer thereof acquainted with the facts recited.

Each application shall be accompanied with a remittance of $100. The application should be prepared in duplicate, and for convenience in filing, on good unglazed paper, 8 inches by 10½ inches, directed to the Federal Trade Commission, Patent, Trademark and Copyright Division. If the licensee is not to be the actual manufacturer, the licensee will be held accountable for the observance of the terms of his license by the actual manufacturer of the article.

The burden of establishing affirmatively the facts upon which licenses may be granted is placed upon the applicant for license. Licenses shall continue during the terms fixed in the license, or during the term of the patent, and upon violation by the licensee of any of the provisions of the act or conditions of the license, the license may be cancelled.

[1]Abstract of "Instructions, Rules and Forms Concerning Patents, Trademarks, Prints, Labels and Copyrights," issued by the Federal Trade Commission under Section 10 of the Trading with the Enemy Act.

POWER REQUIRED FOR DRIVING REAMERS

In order to determine the amount of power required for driving chucking reamers, a series of tests was made at the Worcester Polytechnic Institute by Leon H. Rice and F. Stanley Riggs, seniors in mechanical engineering. While the primary object of these tests was to ascertain the effect of reamer design on the power required for driving reamers of different types, it was found that the general type of reamer and the form of its flutes is of far less importance, so far as the necessary driving power is concerned, than the keenness of the cutting edges. The results of these tests are not regarded as conclusive, since there was no method of standardizing the keenness of the cutting edges nor of determining the relative effects of sharpness and the shape or contour.

The apparatus used consisted of an upright drilling machine, a special form of dynamometer for measuring the torque and platform scales for weighing the downward pressure or endwise thrust. The test piece was held in a lathe chuck mounted upon the dynamometer, which was supported by the platform scale. The dynamometer has a circular table 12 inches in diameter, and a strap made of annealed clock spring was attached to the periphery of this table. The other end of this strap connected with a weighing scale of the spring type which gave the torque readings. In order to avoid inaccurate results due to a turning tendency of the platform of the scale used for recording the downward pressure, this platform was stayed by means of rods and knife-edge bearings. This method proved successful and interfered little, if any, with the vertical action of the platform itself. In addition to this equipment, it was found necessary to use an oil dashpot to prevent the pointer of the torque scale from vibrating to such an extent as to make it almost impossible to obtain readings. This dashpot consisted simply of a pail containing heavy cylinder oil and a large disk submerged in the oil and connected to the table of the dynamometer by means of suitable rods and an intervening bell-crank. With this dashpot connected to the table, any sudden motion of the latter was reacted upon by the resistance of the thick oil as it flowed from one side of the submerged disk to the other side.

The pieces to be tested were made of a good grade of gray cast iron and each one was tested for hardness. New reamers, furnished by the Cleveland Twist Drill Co., were used and were for 1-inch, 1½-inch and 2-inch holes, respectively. The two principal types of reamers tested were the straight and spiral fluted forms. The number of flutes varied from four to fourteen, the four-fluted spiral reamers resembling a four-fluted drill in their action. These reamers were all of the so-called chucking reamer type and cut mostly on the end, very little material being removed along the sides. The holes in the test pieces were cored to 7/8 inch, 1 3/8 inch and 1 3/4 inch diameters, and were drilled, prior to the reaming test, to diameters of 15/16 inch, 1 7/16 inch and 1 15/16 inch, respectively. The torque fluctuated considerably when drilling these holes, which was due to the irregularity of the cored holes. When reaming the holes, these excessive fluctuations did not occur. Readings to determine the general variation in the hardness of the cast-iron test pieces were taken by drilling 3/8-inch holes in the ends of the pieces and measuring the pressure, the average pressure being used in the comparison. The drill was also tested for sharpness by drilling into a sample test bar. Four test pieces were used for each reamer tested, and in this way, by taking the average of the readings, a mean value for the variations in the castings was obtained.

The tabulated results of these tests are given in the accompanying table. The four-fluted chucking reamers gave the lowest pressure and the least torque in inch-pounds, although this type of tool left a comparatively rough hole. The spirally fluted reamers having ten, twelve or fourteen flutes required a little more power than the straight-fluted ones. This difference might have been greatly reduced if the amount of metal removed had been less. The increase in pressure for the spiral flutes could easily be accounted for, since the flutes were left-handed and inclined backward with reference to the direction of rotation. As the table shows, the pressure was always less where there was a reduction of the number of cutting edges.

TORQUE AND PRESSURE FOR DRIVING CHUCKING REAMERS OF DIFFERENT KINDS

Reamer Diameter, Inches	Number of Flutes	Form of Flutes	Reamer Speed, R.P.M.	Torque, Inch-Pounds	Pressure, Pounds
1	10	Straight	125	45.00	31.75
1	10	Spiral	125	51.06	57.25
1	4	Spiral	125	42.12	27.50
1¼	12	Spiral	76	54.75	39.60
1¼	10	Straight	76	57.00	36.75
1 5/16	10	Spiral	76	100.00	68.00
1½	12	Spiral	76	103.80	56.50
1½	12	Straight	76	76.20	40.25
1½	8	Straight	76	70.92	34.25
1½	4	Spiral	76	64.02	20.25
1 9/16	12	Spiral	76	75.00	138.00
2	8	Straight	76	147.72	46.25
2	14	Straight	76	126.00	51.00
2	14	Spiral	76	126.72	63.00
2	4	Spiral	76	93.00	27.50

Note: Feed of reamers per revolution, 0.0153 inch

In making experiments to determine the effect of the keenness of the cutting edges, a reamer approximately one inch in diameter was used. This reamer had been used in the shop for some time, but did not appear to be very badly dulled. The torque and pressure readings were 126 inch-pounds and 134.5 pounds, respectively. The tool was then sharpened and the torque was reduced to 45 inch-pounds and the pressure to 31.7 pounds, thus giving a reduction of 64.3 per cent in torque and 76.4 per cent in pressure. This difference showed very decidedly that the sharpness of the tool has far more influence than the design on the amount of power consumed. Reamers from the tool-rooms of local manufacturing plants were tested, and the results emphasized the fact that, for the same degree of sharpness, the amount of power required to drive chucking reamers of different styles would not differ greatly. The design of the tool, however, might have a decided effect on the length of time that the cutting edge remained sharp. It was not considered practicable to make tests for durability. The tests showed that the most important requirement is keeping the reamer sharp.

* * *

SKILLED MECHANICS REQUIRED BY THE GOVERNMENT

The War Department announces that the army air service needs many more skilled workmen behind the lines abroad. These men must be recruited continuously. The air fighters need the backing of skilled men to keep each airplane ready for instant and constant service, to bring up supplies, ammunition, etc., and to construct and maintain airdromes. There is room for men with special qualifications to become non-commissioned officers. Men are being enrolled from various classes of skilled workers. These men will be given special training according to their vocation in the actual work on airplane motors, trucks, airdrome construction, etc., that they will be required to do in France. Among the skilled workers needed are automobile engine repair men and machinists acquainted with automobile work, electricians, repair men for instrument work, machine gun repair men, machinists and blacksmiths in general, motorcycle repair men, mechanical draftsmen, magneto repair men, metal workers in general, automobile engine testers, airplane propeller makers, airplane assemblers, toolmakers, welders, molders and patternmakers. Applicants must be physically sound and from eighteen to forty years of age. Applications should be sent to the Aviation Section of the Signal Corps, Volunteer Bureau, 119 D St., N. E., Washington, D. C. The application need merely state as follows: "I desire to enlist as a skilled workman in the Aviation Section of the Signal Corps," giving the name and address of the applicant, his present employer, the name of his trade, the number of years he has been employed in the trade, and whether he expects to be drafted under the selective service provisions or not.

CUTTING BOLT CAMS IN RIFLE RECEIVERS

BY H. C. EVANS

In all fixture work there are certain operations, now and again, that present special difficulties because of the peculiar shape of the cut to be taken or the inaccessibility of the surface to be worked upon. In the manufacture of rifle receivers the operation of cutting the bolt cams was one in which both of these difficulties were encountered, and they were overcome by means of the special fixture described in the following article:

The front end of this receiver is shown in section in Fig. 1. The problem presented was cutting away two diametrically opposite corners at the ends of the bolt splines. The purpose of this is to furnish two spiral faces, on which the recoil lugs of the bolt will be drawn forward out of the splines to their position against the face *AB* when the bolt is rotated a quarter turn in pushing the handle down. These two faces, which are alike, are portions of right-hand spirals of 1½ inch lead, and extend 34 degrees from the corner *G* of the bolt splines. The cutter, which is shown at *C*, Fig. 2, is similar to a boring tool with radial cutting edges, being held in the slot of a boring-bar by means of the set-screw *D*. It differs from an ordinary boring cutter only in the angles of rake and clearance, for it must be borne in mind that, instead of moving like a boring tool with only the slight advance per turn necessary for feed, this cutter must move along a spiral of 1½ inch lead, making the direction of the cut along *EF*. It is also evident that as soon as the proper corners have been cut off, the cutter must recede along a left-hand spiral in order that the other corners will remain untouched. This receding movement must be sufficient to bring the cutter into the position shown in Fig. 2, clearing face *AB* as indicated, where it must remain until it has turned to the point where it must begin to cut the opposite corner. This motion was imparted by means of the barrel cam *G*, which was clamped on the boring-bar and turned with it. While the construction and lay-out of this cam will be taken up later, it is well to explain here that two forward and backward movements were given in each revolution, both edges of the cutter doing an equal share, and working on each cut in alternation.

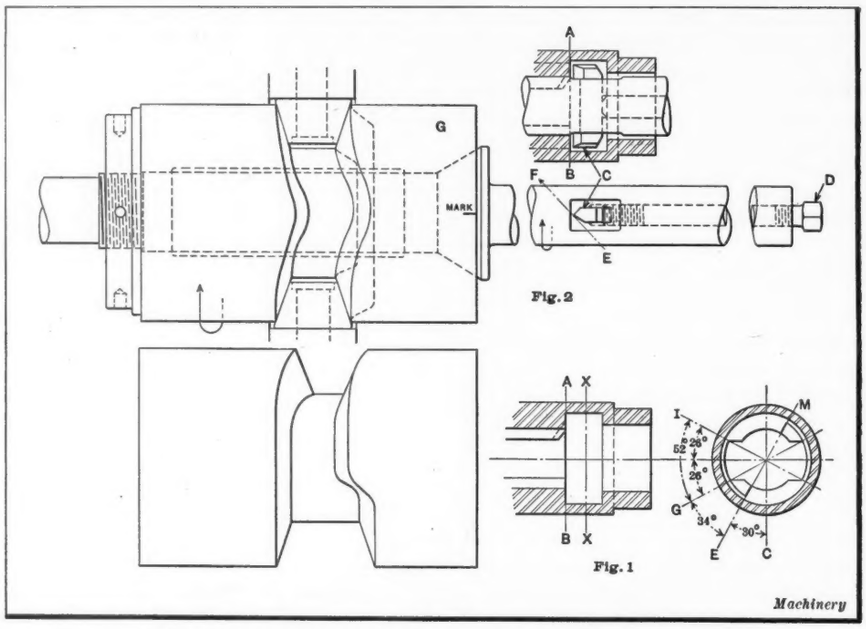


Fig. 1. Front End of Receiver. Fig. 2. Barrel Cam, Cutting Bar and Cutter

Fig. 3 shows the top and front views of the fixture. This was used on a plain milling machine, the feed being to the right as is shown. The cutter-bar *A* turns in the two bushings *B* and *C*, both of which are sliding fits in their supports. The bushing *C* is retained by a slotted spacing piece *D*, swinging on the stud *E*. By lifting this spacing piece out of the way, the bushing *C* may be withdrawn and the receiver slipped onto the cutter-bar, the latter having been turned to bring the projecting ends of the cutter horizontal, allowing them to pass through the bolt splines which have already been cut. A

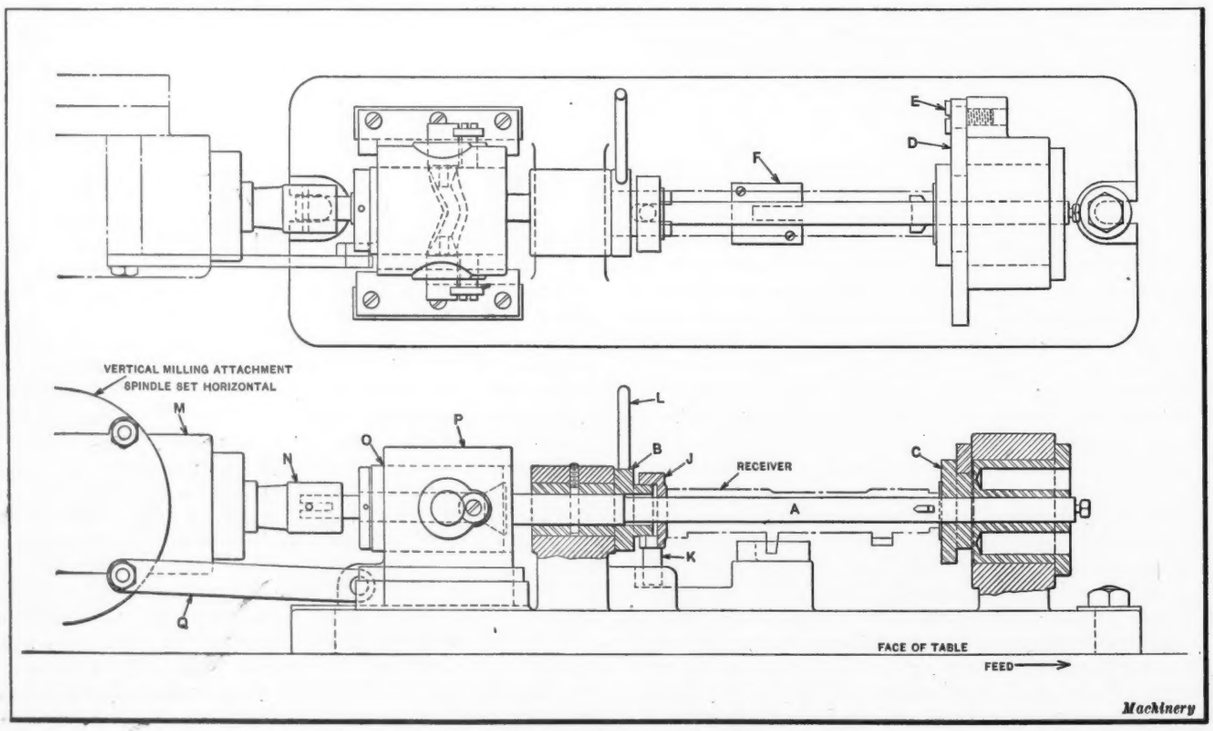


Fig. 3. Fixture for cutting Bolt Cams in Rifle Receivers

slotted plate *F* on the base engages the projecting lug on the receiver and prevents it from turning. The bushing *C* is then replaced and the spacing piece *D* swung down to retain it. The threaded nose of the other bushing *B* carries a nut *J*, which is prevented from turning by the projecting stud *K*. The latter is engaged in a slot in the base, so that by giving bushing *B* a partial turn by means of the handle *L*, nut *J* is brought against the rear end of the receiver, clamping it firmly in place. An ordinary vertical milling attachment was utilized for driving the cutter-bar. Its spindle was set horizontal and provided with a special collet *N*, driving the cutter-bar by means of a slot and pin so as not to interfere with its longitudinal movement. The barrel cam *O*, referred to above, which is carried on the cutter-bar, turns in the housing *P*. This housing, which carries the studs on which the cam rolls turn, is of cast iron and is arranged to slide in guides on the base. A link *Q* between the frame of the milling attachment and the housing *P* serves to keep the latter stationary regardless of table travel, so that the cutter always describes the same path in space. Evidently when the table feed is thrown in, the fixture bearing the work will be carried to the right and the work fed against the revolving cutter. The table movement is small, less than ⅜ inch, and the fixture is so

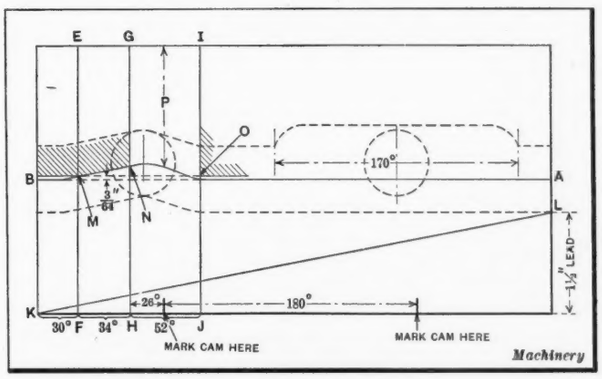


Fig. 4. Development of Cutter Path

set up that at first the cutters barely clip the corners to be cut off, each chip being a little wider until the required depth is reached.

To return to the cam. It was at first thought that there must be two waves opposite each other, since two throws were needed per revolution, but a little study revealed the possibility of using a cam with but a single wave and obtaining two throws per revolution by using two cam rolls placed diametrically opposite. The appearance of this cam is shown in Fig. 2. The active path, which contains but one wave, extends over an arc of 190 degrees. It is evident that this single wave, acting in alternation on two diametrically opposite cam rolls, produces exactly the same effect as two diametrically opposite waves acting on a single cam roll. Thus during the dwell the action passes from one roll to the other, and the cam path is widened for the remaining 170 degrees so as not to interfere with the inoperative cam roll. The advantages of this plan are obvious, for if one wave of a two-wave cam differed slightly from the other, one lip of the cutter would take a thicker chip than its mate. Furthermore, the cost of the cam is materially reduced.

A development of the path of the cutter is reproduced in Fig. 4. This was obtained by laying in a development of the work on the developed cam surface as follows: The line *AB* is first drawn to represent the position of the cutting edges during the dwell. As this occurs while the cutters are opposite the face *AB*, Fig. 1, there must be a clearance between them, so a line 3/64 inch above line *AB* can be taken to represent this face. The left-hand boundary represents point *C*, Fig. 1. A line *EF*, 30 degrees from this, represents point *E*, Fig. 1, or the beginning of the cut, and *GH* and *IJ* at intervals of 34 degrees and 52 degrees represent the corners of the bolt spline *G* and *I*, Fig. 1. Next the lead of the spiral—1½ inch—is laid off at the right of the diagram and *KL* is drawn to obtain its slope. A line *MN* parallel to this is drawn through *M* and represents the spiral cut which is to be taken. As is indicated by the shading, we have now a complete picture of one of the cuts to be taken, and the missing portions of the cutter path can be readily laid in, only taking care to have it clear point *O*, as this corner of the work must remain untouched. The diagram also indicates how the cam path is cut away where necessary to clear the inoperative cam roll. Now if the left-hand part of the development is redrawn on a 10:1 scale, the successive values of *P* at 2-degree intervals can be readily scaled off and tabulated, giving the necessary information for cutting the cam. It should be noticed that what we have drawn is really a development of the cutter path and not of the cam roll path, and that in cutting the cam the distance *P* is to be laid off from the bottom end of the cam instead of from the top end as measured in the diagram. This is due to the fact that since the cam is turning and the cam rolls are stationary, the path must swing to the right in order to move the cam and cutter to the left. In conclusion it may be said that while milling the cam it should be marked as shown, and it should be secured to the shaft with these marks opposite the edges of the cutter to insure correct timing.

* * *

FINANCING THE WAR

In a series of articles in *The Public* on the subject "Financing the War," Louis F. Post, assistant secretary of the Department of Labor, Washington, D. C., calls attention to some of the misconceptions in regard to the importance of money in carrying on the war. The subject is explained by Mr. Post as follows:

> Where will the money come from? This question in one form or another is on the tongue of most persons who talk about financing the war, and at the pen-tip of most of those who write about it. The unusual but absolutely true answer is that very little money will come from anywhere, and that not much would be needed if it came.
>
> The war cannot be financed with money. This is not a dogmatic pronouncement, but a statement of fact which needs only to be considered thoughtfully in order to be recognized as true. No wars are financed with money. It is not money that is borrowed when war bonds are issued, nor money that is confiscated when war taxes are levied. *Labor products, not money, are the things needed and used in war.*
>
> The few pieces of money that are paid for bonds or taxes are taken by the government only as tokens to be passed on for the consumable and destructible things it really needs. What it borrows with the bonds which it issues, or confiscates by the taxes which it levies, is not the money even when it takes money in payment. *Money can neither be eaten nor worn, nor yet loaded into guns and shot at the enemy.* The subjects of governmental borrowing or confiscating for war purposes are the food, the clothing, the munitions, and the like, which come to the government as the pieces of money it happens to take pass on and round-about—mere counters in the flow of exchanges.
>
> Except as a temporary makeshift until equitable and efficient tax legislation for war necessaries can be formulated and adopted, bonds have no justifiable place in the prosecution of a war for democracy. By every democratic test, they at their best are worse than taxation at its worst. In this connection let the economics of war supplies be remembered. Whether borrowed on bonds or taken by taxation, *war supplies must be got from the labor of the present time. They cannot by any possibility be got from the labor of the future.*

* * *

HIGH-POWER RADIO STATION

The Navy's new high-power radio station in the Hawaiian Islands is the most powerful in the world. It is designed for direct communication with Washington and the Philippines. Messages have been exchanged between the stations at Sayville, Long Island, and Honolulu, a distance of approximately 5000 miles, which is the world's record for long-distance exchange of communication by radio. Communication between Washington and the Philippines will easily be accomplished with a relay through the Hawaiian station. This station is one of a chain of high-power radio stations under construction by the Navy Department; the other stations in this chain are Arlington, Darien (Canal Zone), San Diego, Cavite (Philippines), Guam and Tutuila. Each station consists of three steel self-supporting masts to support the aerial. The apparatus is of the Poulsen arc type.

FORMING CARDBOARD SHAPES[1]

BY G. R. SMITH[2]

In the April number of MACHINERY there is a request for information on the blanking and forming of pasteboard, paper, cardboard, plaque and pressboard shapes. As the writer has had quite an extensive experience in this line of press work, he will give a brief description of the manufacture of this product, confining it chiefly to the machines employed. Contrary to general belief, a large, powerful machine is required to form and draw cardboard shapes successfully. The cutting and blanking may be done on small light presses, but the drawing and forming, to be permanent and successful, must have a press with sufficient power to force the cardboard to its required shape and hold it there briefly under great pressure. In nearly all paper and cardboard forming, such as pie plates, picnic plates, candy dishes, labels, covers, drawn pasteboard boxes, etc., the shape must be blanked, or cut, first, as the forming dies cannot be so constructed as to blank and form with the same stroke, as in metal drawing, and the dies for such blanking are the regular solid steel punch and blanking die, both of which are hardened. These dies may be of the two- or four-post, bolster, sub-press type, or the push-through type, depending on the nature of the work to be done and the degree of accuracy required.

About all the average cheap paper and pasteboard forms are blanked, several sheets at a time, on automatic-feed presses with push-through dies. The die must not be too hard, for with dry cutting of this nature, chipping takes place very easily, which soon destroys the dies. These dies are generally drawn down just a trifle softer than dies required to cut sheet metal, and they cannot be of the water-tight, ground-to-fit style. Of course, if they are too loose a fit, the paper will be torn off and not cut, but, on the other hand, if a perfectly tight punch and die is used on this dry work, the stock flakes off and clogs the dies, causing no end of trouble. The fit of the punch and die is largely a matter of individual choice, dependent on the thickness and nature of the stock to be cut. The writer has found a good working fit for tools used to cut paper and cardboard from 0.005 to 0.060 inch in thickness is obtained by grinding the punch from 0.004 to 0.005 inch smaller than the die, which gives a 0.002 inch clearance all around, and then lapping the die 0.010 to 0.012 inch well up to the cutting edge. If the dies are so built, clogging will seldom, if ever, occur, except on pulpy stocks. Of course, it is understood that the thinner stocks, such as tissues and bonds, are always blanked several sheets at once and work perfectly on these dies. This work is cut and blanked dry unless the pulpy or composition stock being worked has a tendency to cling to the punch, when a little clean water or wood alcohol is used to wash out the dies and keep them from clogging. On hard-paper stocks, from 0.004 to 0.015 inch thick, three to ten sheets are cut at a time, while with the pulp papers and heavy cardboards fewer sheets may be cut at one stroke, in some cases but one thickness.

For single-action presses for blanking cardboards and papers, such styles as the Bliss No. 21 is generally used. It is very efficient, as it is inclinable, arranged for gravity feeds, and has many automatic attachments. If automatics are preferred, which really are the producers for such work, a press like the Bliss "No. 3½ Special" may be used. This press takes a sheet up to 40 inches square, or can be arranged to take rolled stock 40 inches wide, and is a full automatic. The stock is placed on a feed belt, which is fitted with adjustable stop-fingers that hold the sheet in position while several blanks are being cut at one stroke of the press. These presses are extensively used on plain sheet, cover, card and blanking work, where only average accuracy is required.

For blanking from lithographed or printed sheets, a press like the Bliss No. 20—PE, zigzag feed, should be used. This press takes the sheets on an automatic sheet carrier, and after the sheet is placed in position, the operator trips the press, but gives it no more attention until it automatically stops when the last blank in the sheet is cut. The sheet carrier then returns to its initial position ready to receive the next sheet. This carrier feeds very accurately and is adjustable so that the printed matter on the sheet will register accurately with the dies. All scrap is divided from the work as it is cut, and the press may be used for heavy cardboard, pasteboard and plaques.

For smaller work, such as cards, labels, etc., the Bliss No. 103 is very efficient. This press takes the stock in strips or rolls and is equipped with a blank-holder and a trip gong, which rings when the pile of blanks reaches a certain number; the number may be varied at will. This press is adjustable, universal, and very rapid, as well as accurate; one operator is able to attend to from one to four presses. Aside from the increased production and room space, the automatics are a great safety factor, as the operator's hands need never be very close to the working dies. This feature alone should commend their use in all shops and on all classes of work for which they are adapted. Their saving in production and accidents more than pays for their initial cost.

After the blanks are cut and ready to be formed, or drawn, they are steamed or dampened. This is as essential an operation as is annealing in sheet-metal working. Of course, it is understood that all grades of paper or cardboard will not form, any more than all grades of metal will draw. The stock must be of such grade as to withstand the stress of drawing, or forming, as well as any excessive local stress that may exist in the shape being manufactured. After steaming or dampening, the blanks are ready for the forming, or embossing, press. Either the forming dies or the bedplate of the press to which they are bolted are steam heated; that is, they contain a chamber through which live steam is conveyed, thus keeping the dies hot at all times. The dies may be made of almost any shape or size and of cast iron, machine steel or tool steel. There is little choice in regard to the metal in the dies, as they are subject to little wear or strain.

Steam-heated dies are required, for they dry the blank as it is held in position under considerable pressure, thus making a permanent shape. The presses generally used for such work are those like the Bliss "No. 55 Paper Drawing" press. The upper die is bolted to the top plate of the press and remains stationary. This plate may be adjusted for pressure, arrangement of dies, etc., by means of the bolts at the top of the press. The amount of pressure required is entirely dependent on the stock being run and the style of work manufactured, the same as when drawing sheet metal; but in any case very little pressure is required. The bottom bed, or bolster, to which the lower die is bolted moves upward and has an extra long dwell, thus holding the paper or cardboard form under pressure for a brief time while it dries in the dies. Thus, at the highest point of the stroke, the article assumes a permanent shape under the action of the steady pressure and heat.

There are many presses on the market for embossing work in metals, papers, cardboards, leather, etc., but the most satisfactory has an adjustable bed and is equipped with automatic die slide and feeds, so that the operator's hands are never very near the dies. Paper may be embossed on light presses, but for a successful emboss, even on light post-cards and magazine covers, a press should have sufficient pressure to smash the very texture of the paper into the forms so that it will assume a permanent shape. This takes a lot of power and requires a large, heavy press. While a great deal of forming and embossing is done dry on light single-action presses, the steamed stock under the action of steady pressure and heat makes a much better piece of work and is permanent, which cannot be said of the lightly formed or embossed goods. Besides the working on paper and cardboards, these presses are extensively used for forming and embossing leather goods, chair backs, furniture, and many wooden products, metals, pressboards, plaques, rawhides, compositions, etc.

* * *

The Minister of Munitions of Great Britain has issued an order by which all iron ore mines in the counties of Cumberland and Lancaster pass into the possession of the government, and under the management of the Ministry of Munitions.

[1] For further information on this subject, see "Cardboard Forming," September, 1917.

[2] Address: 19 Pond St., Pittsfield, Mass.

LETTERS ON PRACTICAL SUBJECTS

WE PAY ONLY FOR ARTICLES PUBLISHED EXCLUSIVELY IN MACHINERY

PORTABLE TUBE-BENDING MACHINE

Having various sizes of tubing to bend and set up in different parts of the factory, it was decided to make, at small cost, a machine that could be brought close to the job being set up,

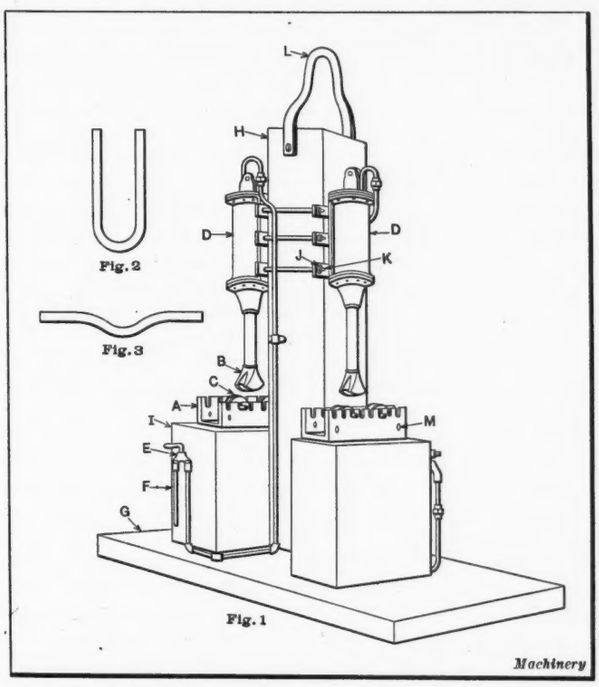


Fig. 1. Handy Tube Bender. Figs. 2 and 3. Bends that are made

and thus save the time spent in going to the machine to make the bend and then back to the work to try the tube in place. Most of the work was special and required more or less cutting and trying so as to make a good job. The machine designed is shown in the accompanying illustration. It was made in tandem so as to enable two men to work simultaneously or so that each side could be set for a different bend, thereby eliminating the necessity of changing the positions of the rolls. One of the air cylinders *D* is twelve inches by twelve inches and the other is eight inches by twelve inches, as these were on hand.

The roll-holder *A* has several slots on each side, cut opposite each other, to hold the shaft that contains the rolls; these slots are spaced so as to obtain the necessary bends. The holes *M* are used for hold-down bolts (not shown) when bending pipe as shown in Fig. 3. The former *B* and the rolls *C* are made to suit the diameter of tube and the radii of bend. The control of the cylinders *D* is obtained by the air valve *E*, which is connected to the main line by a flexible shaft *F*. The frame of this machine, consisting of the base *G* and the uprights *H* and *I*, was made of heavy pine logs bolted together. The cylinders *D* are bolted to three steel straps, which are held to the column by six heavy bolts *J* and *K*. The bail *L* is for the crane hook. Figs. 2 and 3 show two of the bends that are made; right-angle bends can be made, if desired, by strapping down one end of the tube. Miscellaneous straps and bolts are used in connection with the bending, but are not shown.

G. E. P.

MAKING STEEL TENSION COVERS

An order was received for some steel tension covers of the form shown at *B* and *C* in Fig. 1. Either cold-rolled or hot-rolled 20-gage steel could be used, and after studying the requirements, it was decided to do the work in an ordinary inclinable punch press with sufficient power to operate the compound punch and die used for making the covers. At *A* in Fig. 1 is shown the form of rectangular blank from which these covers were drawn and formed. This blank is 3/32 inch wider at the center than at the ends, to allow for the stock which is drawn toward the center due to the concave form of the cover. In order to overcome the tendency of the steel to warp slightly one way or the other, it was necessary to develop the work gradually so as to produce uniform shape and flexibility. In this connection it may be mentioned that when one of these covers is in use it must fit close at all points; and in order to meet this condition it is necessary to have a reverse curve in the cover, so that when it is put in place and tightened with a nut on boss *X*, the cover will settle 1/16 inch at the center, making it perfectly straight and at the same time putting sufficient tension on the nut to keep it from turning off through vibration or any other cause.

Fig. 2 shows the compound blanking punch and die in which these tension covers are made. In order to provide the necessary curvature in the work, blanking punch *B* is tapered 3/32 inch on the cutting edge and flanging section from center *D* to ends *E*. Blanking punch *B* consists of four triangular shaped sections made of tool steel and hardened in oil, three views of one of these sections being shown in detail at the extreme right-hand side of Fig. 2. In working out the design of these punch sections, particular attention was paid to simplifying the work of repairing and grinding the punches as far as possible. When it becomes necessary to grind a blanking punch, these triangular shaped sections are set up on a surface grinder and ground along the cutting edge and also on the 3/32-inch taper which runs horizontally from the center of the punch to the end of flange *Y*. When this flange has been properly ground, the inside of the punch is ground at

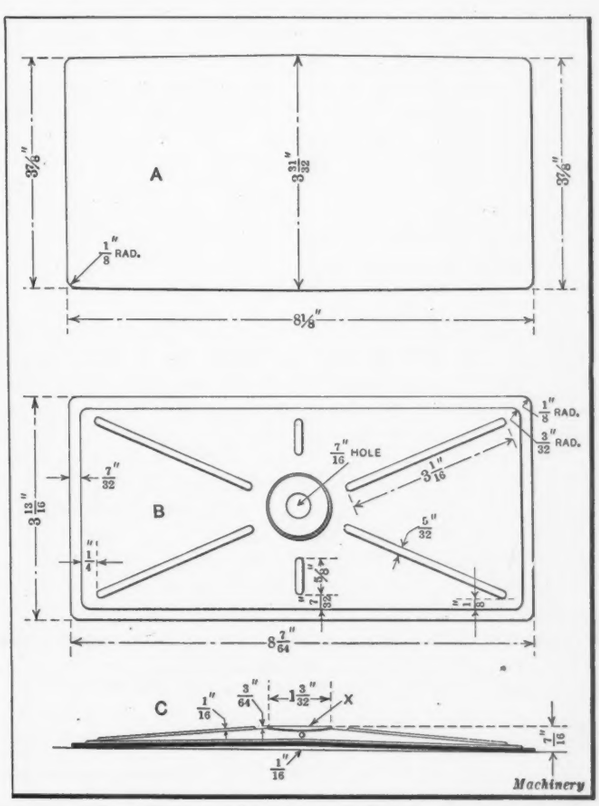


Fig. 1. Sheet Steel Blank A and Finished Tension Cover shown at B and C

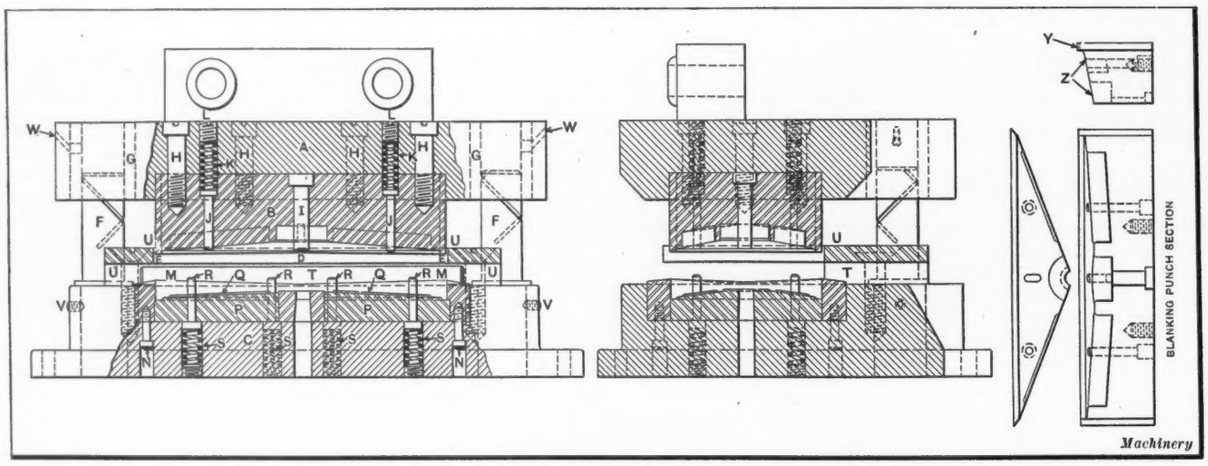


Fig. 2. Punch and Die used for Production of Steel Tension Cover shown at B and C in Fig. 1

the same setting in order to maintain the proper depth at face *Z*. The punch is then assembled ready for subsequent service.

Two views of the blanking punch and die are shown in Fig. 2. The die-shoe *A* and punch-shoe *C* are made of cast iron properly aligned by tool-steel guide pins *F* and bronze bushings *G*. Blanking punch *B* is seated in shoe *A* and held in place by screws *H*. In working out the design of this punch and die, perforating punch *I* was left long so that the perforating operation can be performed before the actual drawing and forming of the tension cover is commenced. In this way the hole is stretched and makes stripping of the cover an easy matter without danger of distortion. Knock-out pins *J* are made of machine steel and actuated by springs *K*, which, in turn, are held in place by set-screws *L*.

The blanking die *M* is made of four steel sections and seated in a cast-iron shoe and bolster plate *C*, being held by screws *N*. These sections have the proper cutting shear. Forming plate *P* is made of one piece of tool steel with an inserted section *Q* for forming beads in the cover. These sections are both hardened in oil, and the under-cut in section *M* assists in holding the forming section *P* in place. Knock-out pins *R*, actuated by springs *S*, serve to eject the finished cover instantly, and by the aid of gravity allow it to slide away through opening *T*. Stripper *U* is held in position by flat-headed screws. A positive stripper of this type was found desirable because it is safer than a spring stripper. As the stripper is held stationary, it cannot accidentally crush a workman's finger if he leaves his hand in an exposed position. Oil-holes leading to the bearings of guide-pins *F* are shown at *W*, these pins being of the stationary type and secured by set-screws *V*. Bolt holes in bolster *C* are used to fasten the die to the press bed.

Highland Park, Mich. ERNEST A. WALTERS

MACHINE DIAL FEEDS

Considerable difficulty was encountered in the manufacture of automatic-press dial feeds in a jobbing shop, the trouble arising in the arcs used for timing the movement of the dial. These arcs were cut by the aid of an indexing head and a milling cutter in a milling machine, but the indexing heads on hand would not give results accurate enough when dividing the periphery of steel disks 11⅞ inches in diameter. As a result, the following method was adopted, as it was more positive.

An angle-iron was laid out, as shown in Fig. 2, with a central hole coinciding with the central hole in the dial plate to be cut, and three small holes *A*, *B* and *C* were made at a given radius. Hole *A* was used to line up the center of the spindle of the milling machine, hole *B* was used for a stop during the operation of cutting the arcs, and hole *C* was used for a stop while milling the driving slots. This angle-plate was strapped to the table of the milling machine and a hole *A* ¼ inch in diameter was indicated up to the center of the milling machine spindle. The dial to be cut was then strapped to the angle-plate and twelve holes were bored through the dial near its periphery, as shown in Fig. 1. These holes formed the back end of the driving slots when the latter were finished as shown in Fig. 3. After these holes were bored, a stop was put through one into a hole in the angle-plate, the milling machine table was run back the required distance, a cutter 3⅜ inches in diameter was inserted into the milling machine spindle, and the arcs roughed out to within 1/16 inch of the correct radius around the dial plate. This cutter was then replaced by a fly cutter and finish cuts taken until the arcs and driving slots were true to a templet. The driving slots between the arcs were milled to maximum and minimum plug gages. There was very little file finishing to be done, and when the presses were assembled the timing of the dials was practically as good as it is possible to obtain.

New Haven, Conn. ERIC LEE

SIMPLE SPRING WINDING METHOD

A method of winding springs was given in the November number of MACHINERY by George Werner, Jr. The writer used this method years ago, and discovered a kink that may be of interest. Light springs of music wire about 0.025 inch in

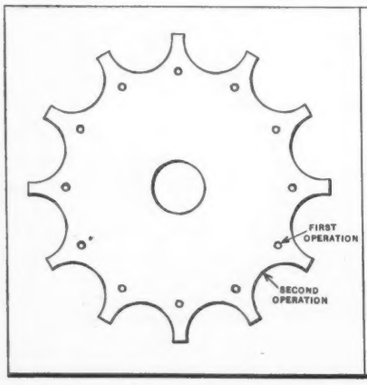


Fig. 1. Dial showing First Two Operations

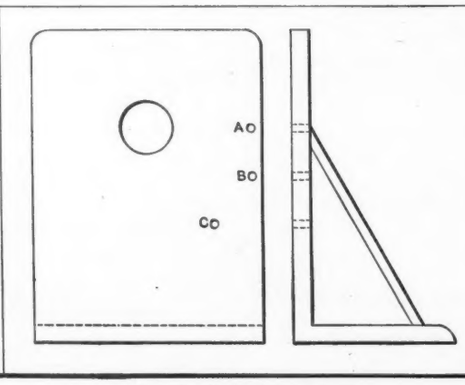


Fig. 2. Angle-plate Lay-out

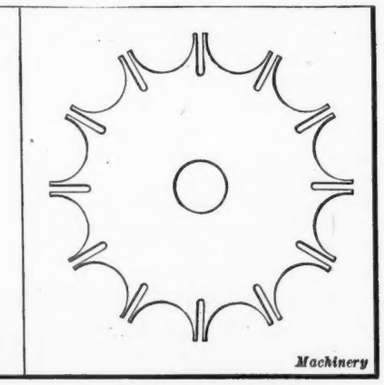


Fig. 3. Completed Dial

diameter were wound by the method described, but the spacer was continuously pressed toward the chuck, and the result was a closely wound spring on the arbor. When the spring was released, the coils expanded to the pitch determined by the pitch of the spacer. In this manner it was possible to make a much longer spring than the arbor ordinarily allowed.

Orange, Mass. H. F. MISENER

EFFICIENCY POINTS IN BORING FIXTURES

As extreme accuracy is the prime requisite in any boring operation, boring jigs and tools are generally more accurate than most machining fixtures. There are many points in boring-fixture design that are being contested, but the details shown in the accompanying illustration have been adopted by expert tool engineers in the production of United States aviation motors. The limits allowed on machined surfaces on this work are less than on much work of equal importance, so that the accuracy of the jigs cannot be disputed.

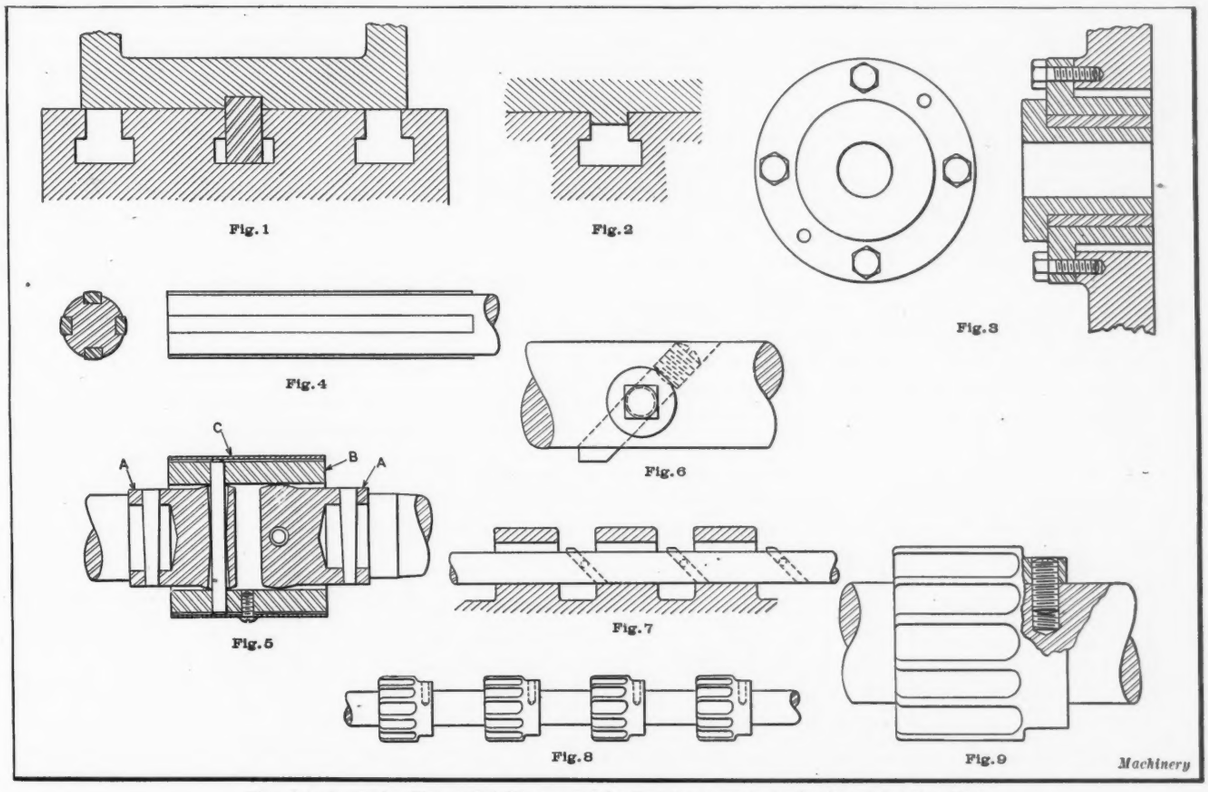
To line up the jig on the table of the machine a planed slot in the casting, used with a steel strip in the table T-slot, as in Fig. 1, seems to be preferred over the method of planing a tongue on the jig base, as in Fig. 2. In the latter method the tongue is likely to become battered and worn and cannot be replaced. The former method is the cheaper; and, besides, if the jig is made to fit a certain machine it cannot be used on a machine that has a narrower T-slot.

Fig. 3 shows an excellent design of guide bushings. The clearance between the large locating bushing and the cored hole in the jig permits a readjustment of the bearing after it has become out of alignment, which always happens in time. This bushing is doweled to the jig, so that to realign it the bushing is loosened, reset, drilled and again doweled. The guide bushing slips into a hardened steel stationary bushing inside the large locating bushing. This construction does not require the accurate boring of the jig at the beginning.

Wearing strips are provided on wearing surfaces of all boring-bars, as in Fig. 4. These are of hardened steel, inserted in four slots in the bar, and after being peened in place, they are ground to size with the bar. After wear takes place, the strips are removed, the bottom of the slot packed up, the strips replaced, fastened and reground to size on the bar. This method always insures the proper fit of the bars in the slip bushings.

Fig. 5 shows a simple, but effective, driving joint for boring- and reaming-bars. Rounded rims are turned on the knuckles *A*, which are pinned to the sleeve *B*, as shown, with pins at right angles to each other. The pin-holes in these knuckles are tapered from the center out, which insures a good driving surface for the pins. The sleeve *C* is merely a sheet-metal cover to keep the pins from falling out.

Single-point boring tools are used rather than the double-edged ones, Fig. 6. One favorable feature of single-point tools is that where several bearings are to be bored, covering a great length, the tools (one for each bearing) can be inserted, adjusted and tightened in the bar before sliding it into the fixture and casting. The guide bushings are removed and the bar slid through the fixture and through the casting with the tools pointing upward. This allows the bar to slide on the bottom of the cored hole and gives plenty of clearance, as shown in Fig. 7. The bars are inserted from the rear end, so that the table of the machine need not be removed after being set.



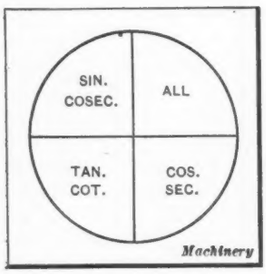
Figs. 1 to 9. Boring Fixture Details approved by Tool Engineers in Production of Aviation Motors

Fig. 8 shows an arrangement of reamers and reamer-bar for reaming a casting of several bearings. Shell reamers are used in this operation, and if the standard taper hole shell reamer were used, the bar would necessarily have several shoulders, one for each taper, giving the telescopic effect, and the smallest diameter of the bar would be entirely too small for accurate alignment. So the reamers are made with a straight hole and the bar has one diameter. The reamers are strung along the bar, and a disappearing driving screw with a shoulder pin is raised with a screwdriver into each reamer after it is put in place, as shown in Fig. 9.

Cincinnati, Ohio JOSEPH A. AHLERS

TRIGONOMETRIC FUNCTIONS FOR ANY ANGLE

In the August number of MACHINERY an answer was given to an inquiry for an easy method of remembering the signs of the various trigonometric functions of an angle in any quadrant. The writer considers the following rule much simpler than the one that was submitted: It is necessary to



Positive Functions for Each Quadrant

memorize the following sentence: "*All* who *sin* are *tanned* as *cost* of transgression." The parts of this sentence that are in italics fit in the respective quadrants commencing at the first, and in this way give the positive functions of that quadrant; referring to the illustration, all functions are positive in the first quadrant, sine is positive in the second, tangent is positive in the third, and cosine is positive in the fourth. Of course, the signs of the cosecant, secant and cotangent have, respectively, the same signs as the sine, cosine and tangent, as they are the reciprocals of the latter. It follows that all the functions not positive in the various quadrants must takes the negative sign.

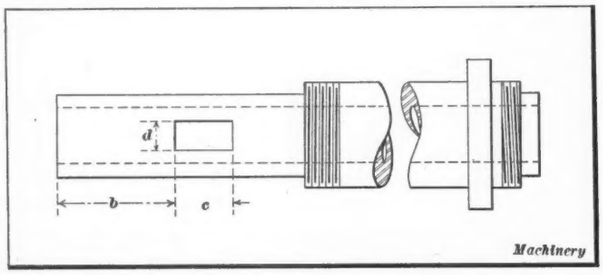
Sheffield, England G. S. BOWLING

WHO BLUNDERED—THE DRAFTSMAN OR THE MACHINIST?

The writer read with interest the article in the November number entitled "Who Blundered—the Draftsman or the Machinist?" Mr. Baker's state of mind upon receipt of the spindles was evidently not an enviable one, but nevertheless, the shop was not entirely at fault. It is the contention of the writer that instructions should have accompanied the sketch, and for this reason the management should not be absolved from responsibility for the error, and neither the draftsman nor the machinist should shoulder the whole blame.

East Rutherford, N. J. GEORGE F. KUHNE

The writer finds the draftsman at fault in the article entitled "Who Blundered—the Draftsman or the Machinist?" on page 250 in the November number of MACHINERY. The accompanying illustration shows the correct drawing that



Correct Drawing of Screw Machine Spindle

should have been sent to the shop. The machinist should not be blamed for turning down the spindles as the sketch indicated. A blueprint of the entire spindle could have been used, with the changes denoted in red or black ink.

Hartford, Conn. E. H. BRUCE

Referring to the article entitled "Who Blundered—the Draftsman or the Machinist?" in the November number, it is the writer's opinion that the break of the spindle is incorrect, because it represents a straight spindle without a step. A break should only occur on a straight, or uniformly changing piece of material, and should not omit any details. The sketch shows a change in the diameter of the spindle in back of the flange and if it were not intended to be different from the original spindle it should have been dimensioned, to indicate that the scale was incorrect. The machinist, unless definitely instructed that the slot was to be the only change, would scale the drawing when he noticed that the sketch was different from the spindle, and assume that the dimension had been omitted and that it was to be the same as at the small end. I say that the draftsman blundered.

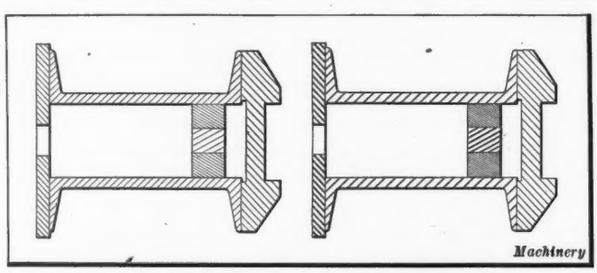
Rockford, Ill. H. T. SHRAM

In the November number of MACHINERY Donald A. Baker shows a sketch for altering some spindles and asks whether the draftsman or the machinist blundered. The answer, of course, will be unanimous. The machinist blundered. Possibly this sort of thing is new to Mr. Baker, but it occurs not only on work sent out, but on work done right in one's own shop. Too much care cannot be exercised in making drawings fool-proof. With no desire to excuse the machinist, it is nevertheless unfortunate that the part of the spindle directly to the right of the break in the sketch *B* scales the same diameter as the part that was to be slotted. In fact, it is unfortunate that anything beyond the break was shown at all. If nothing beyond the break had been shown, there would not have been the slightest excuse for even considering any other operation than slotting. Even at that, some bright youth might cut the spindle in two just beyond the slot without bothering to ask about the teeth.

Jersey City, N. J. H. D. MURPHY

SPACING AND THICKNESS OF LINES IN CROSS-HATCHING

The clearness of a mechanical drawing is largely a matter of contrasts. The lettering and variations in thickness of lines make the drawing clear in proportion to the skill used



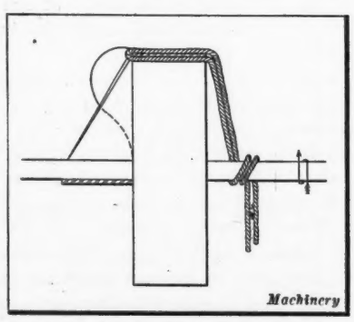
Spacing and Thickness of Lines in Cross-hatching

in arranging them to secure the most effective results. The uses of various lines and letters are generally understood and adopted, yet one of the best ways of making a drawing clear is commonly overlooked, although no additional time or skill is required. The accompanying illustration shows the results obtained by varying the angles, thickness and spacing of lines used in cross-hatching. When skillfully used, this plan makes it possible to secure an effect having the appearance and easily comprehended qualities of a bas-relief.

Pittsburg, Pa. F. D. BUFFUM

PLACING TIGHT BELTS ON PULLEYS

The writer has experienced the difficulty of placing a tight belt on a pulley, and the method employed was, in some respects, similar to that mentioned in the November number of MACHINERY, page 246, but by the following method the same results can be obtained with a greater degree of safety. A rope, the length of which should be at least three times the diameter of the pulley upon which the belt is to be placed, is folded over the belt and the ends made of even length. The ends are then passed over the pulley and wrapped once around the shaft, on the opposite side of the pulley from the belt, in the direction of rotation of the shaft so that the rope will unwind when the shaft is revolved. The belt is then raised to about the same position that it would be if thrown on the pulley in the usual manner, and the rope drawn tight. The power may now be applied, and as the belt starts up slowly it is automatically thrown on the pulley. During this time the rope should be held in the hand, and when the pulley has made about one-half revolution it will be clear of the pulley and tend to travel with the belt. One end of the rope should now be let loose, and pulled clear



Placing Tight Belt on Pulley by Use of Rope

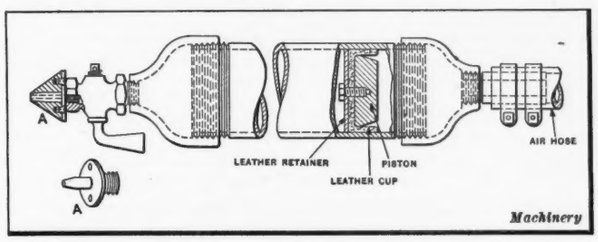
of the belt by the other end. This method removes all danger from the rope hanging to the belt to become a menace to the belt and workmen when delivered to the driving pulley. After a few trials, a tight belt can be placed on the pulley with comparative ease by this method, and often without stopping the main shaft.

Moline, Ill. C. C. HERMANN

GREASE GUN FOR FILLING NEW BEARINGS

By using the grease gun here shown, much time may be saved in filling new bearings. The usual way of lubricating new machines is for the man to screw on the grease cup, fill it with grease and screw down the cap to fill the bearing, then remove the cap and refill the cup. Oftentimes it is necessary to refill the cup several times before the bearings are full of grease; if the gun is used, the bearings are filled before the grease cups are put in place. The nozzle *A* is placed in the grease-cup hole and grease is forced into the bearings with air at a pressure of between sixty and one hundred pounds.

The gun is made of pipe that is bored smooth on the inside. To fill it, the lower reducing coupling, to which the valve and nozzle are attached, is removed and the piston is pushed back to the farther end. The nozzle *A* is protected with a rubber



Grease Gun operated by Compressed Air

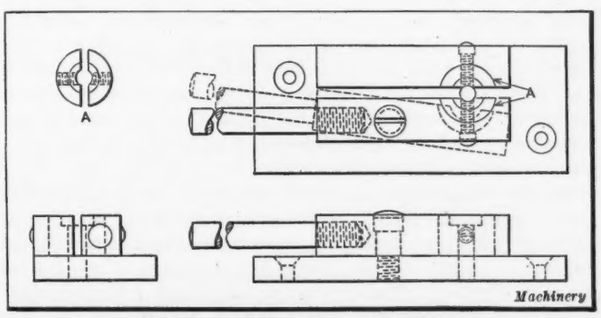
or leather cone as shown. This gun may be used to fill roller bearings, plain bearing grooves, grease holes, or other parts with grease, and as the grease is forced in, all the parts are well lubricated.

Flint, Mich. C. C. SPREEN

DRILL PRESS WORK-HOLDER

The illustration shows a fixture that was designed for the purpose of holding in proper position pieces to be burred, countersunk or drilled, and handling them rapidly. It consists essentially of a stationary bed-plate, attached to the drill press, and a movable arm. In the movable arm is a semicircular recess opposed to a similar recess in the fixed piece. In these recesses are fastened bushings *A* of a size and shape corresponding to the exterior of the piece on which the work is to be done. The arm swings on a stud, and has a handle of suitable length to furnish sufficient leverage to hold the piece firmly in position during the operation. It opens or closes with a single movement, permitting the rapid insertion and withdrawal of the work, so that the speed to be attained depends only upon the quickness of the operator and the time required for the operation of the machine. By the use of different sizes and shapes of bushings, this device is adaptable for many drilling operations.

Boston, Mass. JOHN A. SHAND



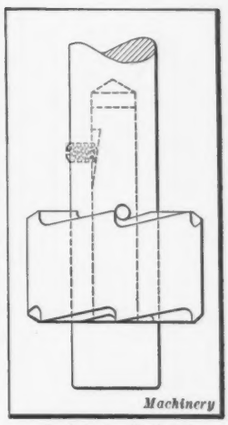
Device for holding Work on Drill Press

SPOT-FACING TOOL AND COUNTERBORE

The accompanying illustration shows a form of spot-facing tool and counterbore not included by F. B. Jacobs among the spot-facing tools described by him in the August number of MACHINERY. The economy of material and time in this form commend it, for each side is notched and ground for cutting. Projecting pins on the bar, engaging the notches not in use for cutting, serve as drivers, as shown in the illustration.

WILLIAM S. ROWELL

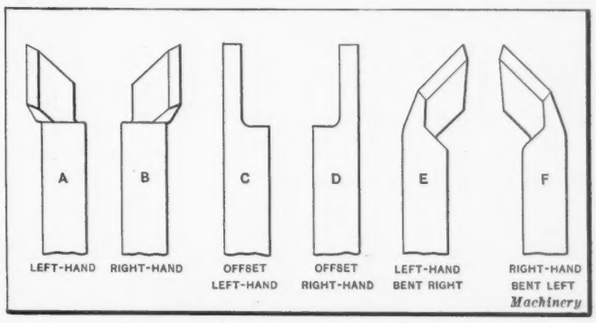
Wilkinsburg, Pa.



Spot-facing Tool and Counterbore

RIGHT- AND LEFT-HAND TOOLS

In the September number of MACHINERY, page 60, was an article on right- and left-hand tools, some of the statements in which the writer does not agree with. Suppose a workman, in picking up a tool, holds it with the butt end toward him and the cutting edge from him; if the cutting edge is on the left-hand side it is a left-hand tool because it cuts toward the left; if the cutting face is on the right-hand side it is a right-hand tool because it cuts toward the right. This is the opposite to the claim made in the article mentioned. The writer knows of a number of well-equipped and efficient machine shops where the terms here given have been adopted. These tools are shown in the illustration at *A* and *B*. In the writer's opinion the terms "left-bend" and "right-bend" are awkward. If a workman desired to cut close to a shoulder with a left-hand tool, he would require a tool bent to the right to give the desired result, or a left-hand tool bent right, and



Names of Lathe Tools that are commonly used

this wording would follow his line of thought. This contrasts favorably with left-hand tool right-bend. The terms "offset" and "bent" are also confused. "Offset" defines a tool on which the cutting edge retains the same relation to the shank as on an ordinary tool but is set either to the left or right, as illustrated by *C* and *D*. "Bent" defines a tool that has the line of the cutting edge bent either left or right at an angle with the shank as shown by *E* and *F*.

It would seem that in these days of unskilled workers in the machine shops, the names of tools should be simplified in favor of the most obvious term. The writer is of the opinion that if several men who knew nothing of machines or tools were shown tools of various hands and bends, their definitions of the tools would coincide with his views. Therefore, if men new in the mechanical field define something in its most obvious form, which men long in the field admit but lack the courage to change, why place the new man under a handicap imposed by improper reasoning and custom? R. L.

ANGLE OF REST OF SHELLS

The angle of rest of shells can be found by a much simpler method than that given in the September number of MACHINERY; the method given in the following does not require an extensive knowledge of mathematics. The diagram given in that

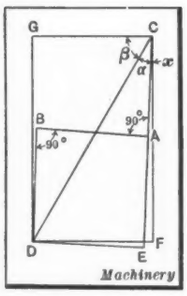


Diagram illustrating Angle of Rest of Shells

solution is slightly modified, and all unnecessary lines are omitted. Points C and D are the centers of the two given circles. The horizontal distance GC between the centers is 60 inches. The vertical distance DG between the centers is the sum of the radii of the circles minus the distance they would overlap, if their centers were in the same vertical line, or $(56 - 6) + 48 = 98$ inches. In the right triangle DGC, the length of hypotenuse $DC = \sqrt{DG^2 + GC^2} = \sqrt{98^2 + 60^2} = 114.90866$. In the right triangle, DEC, the side $CE = CA + AE = 48 + 56 = 104$ inches. Hence, $\cos \alpha = \frac{CE}{CD} = \frac{104}{114.90866} = 0.90507$ and angle $\alpha = 25$ degrees, 10 minutes. From the triangle DGC, angle β may also be easily found for $\tan \beta = \frac{DG}{GC} = \frac{98}{60} = 1.6333$; so $\beta = 58$ degrees, 32 minutes. The required angle x is therefore $90 - (\alpha + \beta) = 90$ degrees $-$ 83 degrees, 42 minutes $= 6$ degrees, 18 minutes.

Fitchburg, Mass. V. CHARUSHIN

The following method of finding the angle of rest of shells differs somewhat from that given in the September number of MACHINERY; yet it produces absolute results. Using the dimensions given by L. J. F., in the accompanying illustration, $CD = 48 + 56 - 6 = 98$. Tan $\alpha = \frac{60}{98} = 0.61224 =$ tan 31 degrees, 28 minutes, 37 seconds. $AC = \frac{98}{\cos \alpha} = \frac{98}{0.85285} = 114.909$. $CF = 48 + 56 = 104$. Cos $\alpha = \frac{104}{114.909} = 0.90506 =$ cos 25 degrees, 10 minutes, 3 seconds. $\gamma = \alpha - \beta = 31$ degrees, 28 minutes, 37 seconds $-$ 25 degrees, 10 minutes, 3 seconds $= 6$ degrees, 18 minutes, 34 seconds.

Another solution was suggested by one of the boys at the shop, W. J. Billerbeck. This method, with the figures presented by B. V. D., is also shown by the illustration. $CD = 0.125 + 0.045 - 0.05 = 0.12$. Tan $\alpha = \frac{0.16}{0.12} = 1.3333 =$ tan 53 degrees, 7 minutes, 45 seconds. $AC = \frac{0.16}{\sin \alpha} = \frac{0.16}{0.79999} = 0.2$. AE and EC are proportional to AH and CJ, respectively; therefore:

$$EC = \frac{CJ}{AH + CJ} \times AC = \frac{0.125 \times 0.2}{0.170} = 0.14706$$

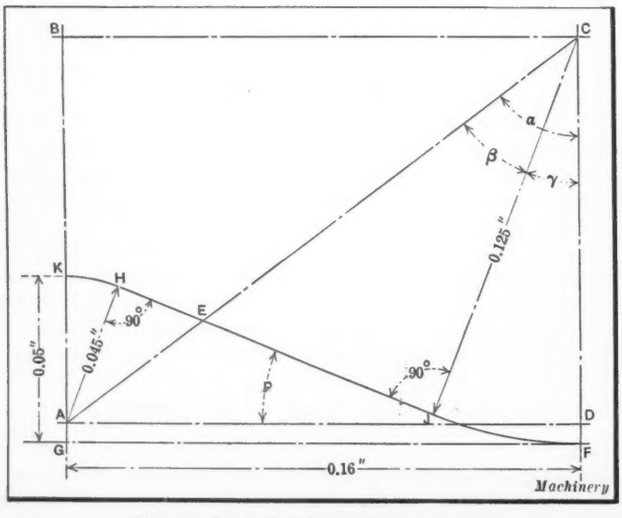


Diagram illustrating Angle of Rest of Shells

Cos $\beta = \frac{CJ}{EC} = \frac{0.125}{0.14706} = 0.84999 =$ cos 31 degrees, 47 minutes, 20 seconds. $\gamma = \alpha - \beta = 53$ degrees, 7 minutes, 45 seconds $-$ 31 degrees, 47 minutes, 20 seconds $= 21$ degrees, 20 minutes, 25 seconds.

Philadelphia, Pa. HARRY S. KARTSHER

BALANCING SCREW PROPELLERS

The method of balancing a propeller on horizontal ways shown on page 137 of the October number of MACHINERY appears to be incorrect; a balance so obtained on a screw originally out of balance on the ways might result in its being worse than before, when in actual service; especially a three-bladed wheel. The method is unsuitable when used with driving pulleys, but should never be applied to a ship screw.

We will assume that one blade A is light and that the overweight is due to insufficient thickness on the advancing side, or lack of density of the metal in the part, say near the periphery. All three blades might be of exactly the same weight, as shown by platform scales, yet unless the weight were equally distributed from hub to rim in all three, the assembled wheel might be out of balance on the testing ways.

That one blade is preponderant will be indicated on the horizontal ways (preferably knife-edges; and the arbor must be smooth and perfectly cylindrical). But this will not show whether the extra weight is equally distributed, or near the hub or the rim, or at the advancing or following edge of the blade in question. So, as the addition of weights to the light blade is not permissible, as in the case of driving pulleys, some weight must be taken off the two heavy blades until the propeller rolls easily and stays still with any one blade up.

If the deficiency on blade A should happen to be on the advancing edge and the other blades are lightened equally over their entire width, or still worse if they are chipped on the following edge, until the wheel is in indifferent balance (that is, stays put, no matter which blade is vertical) the wheel, when in service, will be more out of true than before the "cure." The heavy following edge of A will tend to cock that blade outward and forward, and the heavy advancing edges of B and C will tend to cock these blades outboard and sternward; especially when the wheel races as the ship pitches.

It is just as true of a ship screw as of a driving pulley or a millstone, that the only way to secure running balance is to mount the screw on a cock-head at its center of volume and run it about a vertical axis at the maximum speed at which it is to be driven in actual service. It stands to reason that a three-blade screw is more difficult to balance, either on ways or on a cock-head, than one with only two wings.

New York City ROBERT GRIMSHAW

WEAR IN MICROMETER SCREW

W. S. Rowell's article entitled "Wear of Micrometer Screw and Nut," on page 156 of the October number of MACHINERY, seems to need a few additions. It has correctly described adjustment and said little about wear. Wear will take place so differently in the two cases shown that it deserves attention; both cannot be right. The differential screw has been used (as shown) in a number of makes and styles of micrometers for years; but as part F has approximately twice the number of threads of part E, it should be the nut and take the thrust and wear, and E should be the auxiliary, or tension nut. In other words, a two-part nut, proportioned as shown, should be adjusted as in Fig. 2, so that twelve threads will take the thrust and wear, instead of as in Fig. 1 where but seven threads receive them.

All the thrust, and therefore the wear, on a micrometer screw is from the anvil, and adjustment should be made so as to receive it on a reasonable number of threads, leaving the smaller number to act as guides and producers of the desired friction, or "feel." Hence, if the lead of thread T is more rapid than that of screw M, part F should be screwed into the

micrometer hub to obtain correct wearing conditions; if slower, it should be screwed out of the hub to obtain the correct wearing conditions shown in Fig. 2.

Buffalo, N. Y. WILFRID J. THOMPSON

PROBLEM IN TRIGONOMETRY

The method used in solving the "problem in trigonometry," on page 245 of the November number of MACHINERY, is unnecessarily laborious, as the problem does not involve any trigonometric computations at all. A line joining point D with apex B is exactly the same length as the line DC; therefore, $9/16^2 + (7\,1/4 - x)^2 = x^2 + 3\,11/16^2$. Expanding, cancelling, transposing and reducing gives $x = 2.709$. Then $DC = \sqrt{2.709^2 + 3.688^2}$. W. S. M.

In his solution of a problem involving a gear and three pinions, C. O. H. does not state that the pinions are of equal diameter, although his solution seems to indicate that they are. The following solution is much easier than the one given. Designating the triangle to the right of BC as BCM gives three similar triangles, BCM, CEG, and EDF. The dimensions of triangle CEG are exactly one-half the corresponding dimensions of triangle BCM. Hence, $GC = 2.125$ and $EG = 3.625$. $DF = 3.6875 - GC = 3.6875 - 2.125 = 1.5625$. Now $CM:DF = BM:EF$, or $7.25:1.5625 = 4.25:EF$. $EF = 0.91594$. $X = EG - EF = 3.625 - 0.91594 = 2.70906$. $DC = \sqrt{2.709^2 + 3.6875^2} = 4.5756$.

South Meriden, Conn. D. F. MORIARTY

DEOXIDINE PROCESS FOR CLEANING STEEL

In the October number of MACHINERY is an article entitled "Removing Iron Plate Rust." The method of removing rust suggested may be satisfactory for that purpose, but if paint should be applied over the surface thus treated, it would prove very unsatisfactory, owing to the fact that enough of the chemicals would be left to cause rust under the paint. In order to produce a satisfactory surface for painting, after applying the sodium acid sulphate and then washing with alkaline solution, the surface should be treated with a neutralizing agent such as "Deoxidine," a relatively new chemical which is being used extensively by the steel automobile body makers for preparing the surface for painting. This chemical removes all rust-forming substances and leaves a perfect surface.

New York City J. H. GRAVELL

KINK FOR CROSS-SECTIONING DRAWINGS

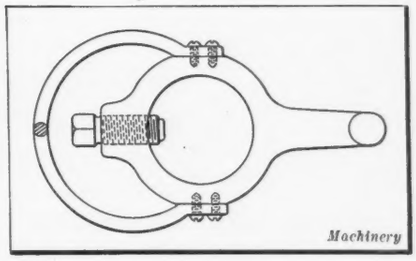
A suggestion for uniformly spacing cross-section lines on drawings, was made in the November number of MACHINERY, page 249, and the writer desires to make several criticisms. The draftsman would need to wait until the line drawn had become dry, before being able to draw the next one, as it is necessary to move the triangle over the line drawn in order to measure the distance to the next. The writer also contends that uniformly spaced lines are not required in drafting or engineering, and in some concerns the cross-section lines are simply drawn free-hand. The uniformly spaced lines do not add to the technical value of the drawings, but are used for appearance only.

Cincinnati, Ohio TAFT S. ARMANDROFF

STRAIGHTENING THIN-WALL TUBING

In the November number, page 252, H. E. G. requested information concerning the straightening of brass tubing. A large tube manufacturer in Waterbury, Conn., uses a straightening machine that is built by the Torrington Mfg. Co., Torrington, Conn. It contains twelve rolls having grooves to fit the tubing. The work is fed in at one end of the machine, and at the other end a man is stationed who receives the tubes and snaps them on a long wooden table. The machine does not straighten the tubes perfectly, but takes out the short bends and kinks, and by snapping them against the table they are made so straight that no error can be detected by the eye. The tubes are then rolled on a long, flat table for the purpose of inspecting.

WALLACE B. SMITH
Waterbury, Conn.



Dog with Safety Device

GUARD FOR DOG

The illustration shows an admirable safety appliance for a dog. A piece of round cold-rolled steel wire is bent and machined as shown, and then fastened to the finished sides of the dog by button-head screws.

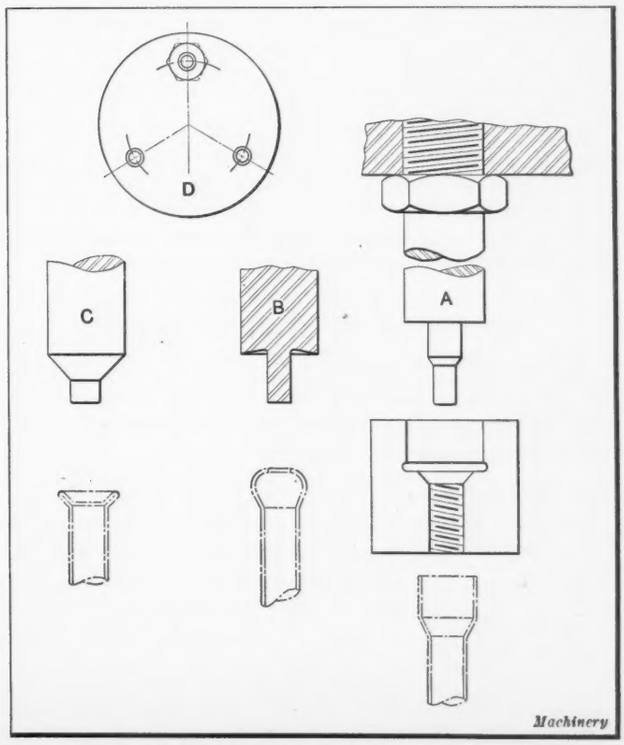
Milwaukee, Wis. FRED FRUHNER

PUNCHES AND DIE FOR FLANGING COPPER TUBING

A shop having a large quantity of copper tubing to be flanged for gasoline connections found it impossible to get a leak-proof fit unless a fold flange was made. Therefore the punch and die arrangement here shown was designed. The single die used is split in the center, one half being stationary and the other half being actuated by a cam and lever. The tubing is pushed into the die from the bottom and is held by the threads in the lower portion. A simple gage insures the tubing being pushed in the correct distance each time.

The first punch A merely enlarges the tubing slightly, the second punch B starts it in a curve toward the center, and the punch C presses it firmly upon itself, forming a well folded flange. These punches are screwed into a rotating plate D, which indexes about at each stroke, bringing the punches into line in rotation. They are threaded into this plate and are provided with lock-nuts for adjustment. This plate is set so that the center of the ram is directly over the punch in operation, and clearances are provided in the bed for the other two punches. This fixture works rapidly and the tubing is so flanged that no trouble is experienced in assembling. The press is turned on its side to make it easier to place the tubing in the die, and a conical recess is used to guide the piece.

Alma, Mich. LLOYD L. LEE



Punches and Dies for forming Fold Flanges on Copper Tubing

HOW AND WHY

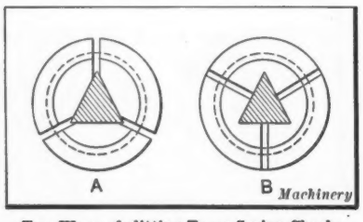
QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

GRADUATION OF TAPER ATTACHMENTS ON METRIC LATHES

T. A.—In furnishing taper-turning attachments on metric lathes for use in France, should the attachment be graduated in degrees or millimeters taper per meter?

A.—The taper attachment on metric lathes for use in France should be graduated in degrees and not in millimeters taper per meter.

WHICH WAY IS CHEAPER ?



Two Ways of slitting Taper Spring Chucks

R. G.—We recently had an order for several hundred taper spring chucks, to hold triangular stock, that could be slit in either of the ways shown here. Which is the cheaper method and how should the slitting be done?

RADIUS AND ARC

O. L. B.—What is meant by the term often used in toolmaking "formed to a radius"? I maintain that it is not correct.

A.—The term "radius" is often misused for "arc." The radius of a circle is the distance from the center to the circumference; and the arc is a portion of a circumference. To say that a tool is formed to a radius of ¼ inch is not strictly incorrect, but hardly good form. The meaning is that the tool is made with a cutting edge conforming to an arc having a radius of ¼ inch. A better expression would be "formed to an arc having a radius of ¼ inch."

EFFECT OF TOOL HEIGHT WHEN TURNING ANGLES

A. V. M.—The seat on a valve disk is faced off in a lathe with the compound rest set at an angle of 45 degrees. A cut is taken off the disk with the tool set on the level of the centers of the lathe. Now, if another cut is taken with the tool slightly above or below the lathe centers, will there be any change in the angle of the seat, the compound rest remaining set at an angle of 45 degrees?

A.—The tool point will turn the valve seat at an angle of 45 degrees only when set at the height of the lathe centers; if set above or below the level of the lathe centers, it will generate a curve, and the angle will differ. It is important when turning tapers and angles in the lathe always to set the tool point at the height of the lathe centers.

PROBLEM IN TRIGONOMETRY

F. L. L.—Will you please tell me how to find the angles of a right triangle when the difference between the hypotenuse and the greater leg is equal to the difference between the two legs?

A.—Referring to the illustration, C is the hypotenuse, A is the greater leg, and B is the shorter leg. Then, $C - A = A - B$, from which, $C = 2A - B$. But $C^2 = A^2 + B^2$. Substituting the value of C previously found, $4A^2 - 4AB + B^2 = A^2 + B^2$; from which $B = 3/4A$. Hence, when $A = 4$, $B = 3$, and $C = 2 \times 4 - 3 = 5$. Therefore, $\sin \beta = 3/5 = 0.6$, and $\beta = 36$ degrees, 52 minutes, 11.63 seconds. Angle $\alpha = 90$ degrees $- \beta = 90$ degrees $- 36$ degrees, 52 minutes, 11.63 seconds $= 53$ degrees, 7 minutes, 48.37 seconds. Any other value than 4 might have been substituted for A, and the result would have been the same.

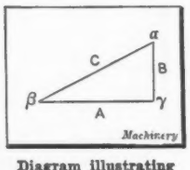


Diagram illustrating Problem in Trigonometry

J. J.

STRENGTH OF CAST-IRON CYLINDERS

J. D.—The cast-iron cylinder A shown in the accompanying illustration is finished all over and has a stem B that is clamped in a bearing C by a cap D; is the cylinder safe against rupture at point E?

Answered by John S. Myers, Philadelphia, Pa.

The question as propounded does not state the purpose of cylinder A or whether there are any external forces acting upon it. In the absence of such information it may be assumed that the weight of the cylinder is the acting force. The weight of the overhanging part is $W = 0.7854 \times 18^2 \times 40 \times 0.26 = 2646$ pounds. This force acts at the center of gravity of the cylinder, or a distance $L = 20$ inches from the face of the bearing. If the stem B extended through the bearing, was threaded, and had a liberal sized nut clamping the shoulder against the bearing, it would be proper to consider the influence of the shoulder. In this case a rough-and-ready approximation of what takes place is about all that the uncertainties of the problem seem to warrant. Such an approximation is to take the fulcrum point F about in the center of the shoulder, and the center of the tensile forces T about one-half the radius of the stem above the center line. These forces F and T are equal and opposite, and constitute a couple having a lever arm of 8½ inches. The bending moment is then $2646 \times 20 = 52{,}920$ inch-pounds, and the value of the tensile forces T is $52{,}920 \div 8.5 = 6226$ pounds. The area of metal resisting this force may be taken as one-third the area of the stem or, area $= 1/3 \times 0.7854 \times 8^2 = 16.75$, say 16 square inches. The tensile stress is then $6226 \div 16 = 389$ pounds per square inch, a very low stress.

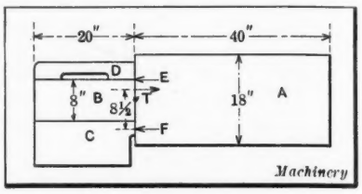


Diagram illustrating Strength of Cast-iron Cylinders

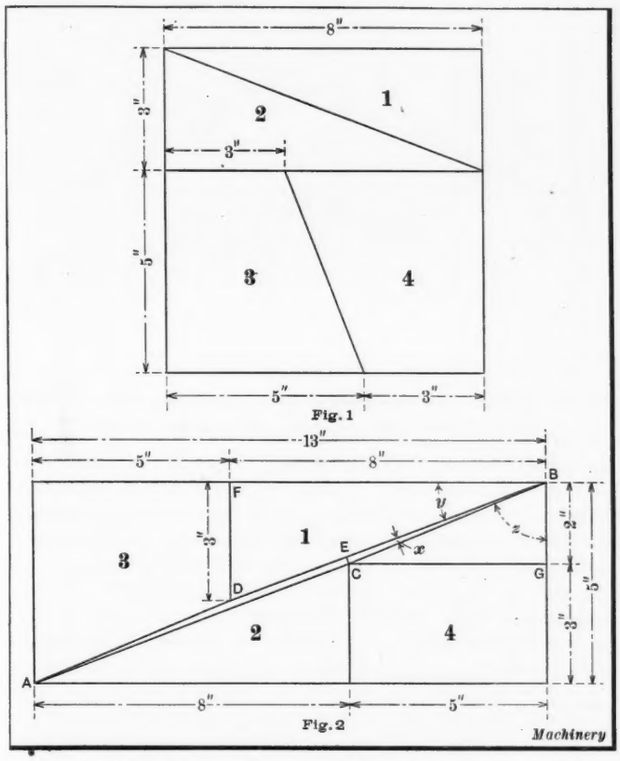
Without some such clamping medium as a nut on the back of the stem, it would not be good engineering practice to consider the influence of the shoulder. In this case, it is necessary to consider the bending moment as maximum a short distance inside the bearing, say 1 inch from the shoulder. The lever arm L is then 21 inches and the bending moment is $2646 \times 21 = 55{,}566$ inch-pounds. The section modulus of the stem is $\frac{3.1416 \times 8^3}{32} = 50.26$; say 50. The stress is then $55{,}566 \div 50 = 1111$ pounds per square inch, which is a safe value for cast iron. In constructions of this sort it is considered good practice, however, to put a liberal fillet in the corner where the stem joins the body of the cylinder, in order to avoid concentration of stresses at this point.

SOMETHING FROM NOTHING

The following gives an exact solution of the problem given by J. B. in the How and Why column in the July number of MACHINERY: Divide the figure as shown in Fig. 1 and arrange the parts as in Fig. 2. From Fig. 2 $ADBC$ is a parallelogram, AD being parallel to CB and AC parallel to DB, with CE perpendicular to DB. Hence its area $= DB \times CE$. To find CE, we must find the angle $EBC = x$, which equals the difference between the sum of the angles DBF and CBG and 90 degrees. Since $y + z + x = 90$ degrees, then $\tan (y + z + x) = a$; and from trigonometry we have the relation:

$$\text{Tan } y \tan z + \tan y \tan x + \tan z \tan x = 1 \qquad (1)$$

From the right triangles DBF and CBG, we find $\tan y = 3/8$, and $\tan z = 5/2$. Inserting these values in Equation (1), we



Figs. 1 and 2. Diagrams illustrating Fallacy of attempting to obtain Something from Nothing

find $\tan x = 1/46$. Length of $CB = \sqrt{2^2 + 5^2} = \sqrt{29}$, and $CE = CB \times \sin x$. Since $\tan x = 1/46$, $\sin x = \dfrac{\tan x}{\sqrt{1 + \tan^2 x}} = \dfrac{1}{\sqrt{2117}}$. Then:

$$CE = \sqrt{29} \times \frac{1}{\sqrt{2117}} = \frac{1}{\sqrt{73}}, \text{ and } DB = \sqrt{3^2 + 8^2} = \sqrt{73}$$

Therefore the area of parallelogram $ADBC = DB \times CE = \sqrt{73} \times \dfrac{1}{\sqrt{73}} = 1$ square inch.

The above gives an exact proof that the area of the material in either figure is 64 square inches. The apparent possibility of this problem lies in the fact that angle x is a very small angle, *i. e.*, 1 degree, 14 minutes, 43.3114 seconds. W. W. J.

CONCERNING SHELL FUSE GAGES

J. J. W.—The inquirer sends two geometrical problems that he states recently came up in connection with shell fuse gages; he gives a trigonometrical solution and asks if there is a simpler solution.

A.—In the problem shown in Fig. 1, distances a, b and radius r are known and it is required to find x and y. The solution given is as follows: $c = \sqrt{a^2 + b^2}$; $\sin \alpha = \dfrac{c}{2} \div r$. This gives the value of α. $\beta = 90$ degrees $- \alpha$; $\tan \gamma = \dfrac{b}{a}$; $\theta = \beta - \gamma$; $x = r \times \sin \theta$; $y = r \times \cos \theta$. This solution is probably as simple as any that can be derived by trigonometry; the following, however, is much simpler. In the right triangles ODC and OBA, $CD = x$, $OD = y$, $AB = x + b$, and $OB = y - a$; hence:

$$x^2 + y^2 = r^2 \quad (1)$$

$$(x + b)^2 + (y - a)^2 = r^2 \quad (2)$$

Expanding Formula (2) and subtracting (1), we have:

$$2bx + b^2 - 2ay + a^2 = 0$$

from which:

$$x = \frac{2ay - (a^2 + b^2)}{2b}$$

Substituting this value of x in (1):

$$\frac{4a^2y^2 - 4a(a^2 + b^2)y + (a^2 + b^2)^2}{4b^2} + y^2 = r^2$$

Clearing of fractions, combining, reducing, and rearranging terms:

$$4(a^2 + b^2)y^2 - 4a(a^2 + b^2)y = 4b^2r^2 - (a^2 + b^2)^2, \text{ or}$$

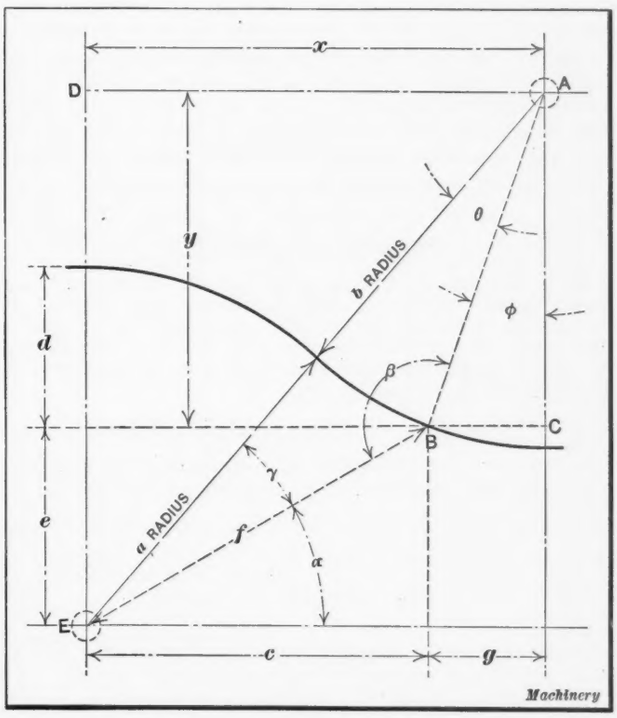


Fig. 2. Diagram illustrating Second Shell Fuse Gage Problem

$$y^2 - ay = \frac{b^2r^2}{a^2 + b^2} - \frac{a^2 + b^2}{4}$$

Solving this quadratic equation for y:

$$y = \frac{a}{2} \pm \sqrt{\frac{b^2r^2}{a^2 + b^2} - \frac{b^2}{4}}$$

This is a simpler solution; because it does not require the use of trigonometric functions and will give results correct to as many figures as are required; it also employs simpler branches of mathematics.

In the problem shown in Fig. 2, the distances c and d and the radii a and b are known and it is required to find x and y.

The inquirer's solution is: $e = a - d$; $f = \sqrt{c^2 + e^2}$; $\tan \alpha = \dfrac{e}{c}$; $\cos \beta = \dfrac{b^2 + f^2 - (a + b)^2}{2bf}$; $\sin \gamma = \dfrac{b \times \sin \beta}{a + b}$. Then, $x = (a + b) \cos (\alpha + \gamma)$ and $y = (a + b) \sin (\alpha + \gamma)$. As in the case of the first problem, there is a solution that uses only the most elementary principles of algebra and geometry. Consider the two right triangles ACB and ADE. $AC = y$, $BC = x - c$, $AD = x$, and $DE = a - d + y$. Hence:

$$y^2 + (x - c)^2 = b^2 \quad (1)$$

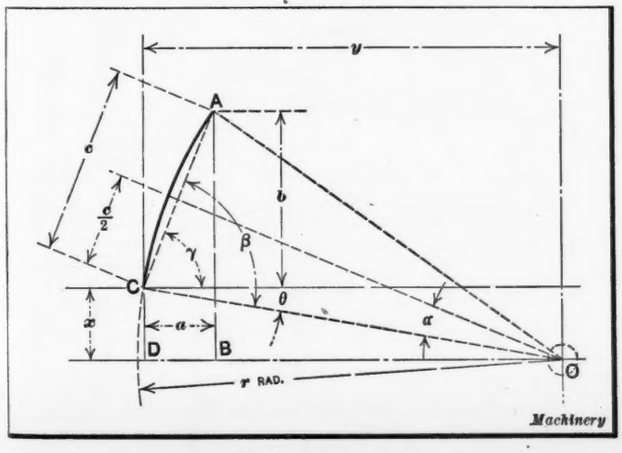


Fig. 1. Diagram illustrating First Shell Fuse Gage Problem

$$(y + a - d)^2 + x^2 = (a + b)^2 \quad (2)$$

Equations (1) and (2) contain x and y and the four known quantities a, b, c, and d. Expanding:

$$y^2 + x^2 - 2cx + c^2 = b^2 \quad (3)$$

$$y^2 + x^2 + 2(a - d)y + a^2 - 2ad + d^2 = a^2 + 2ab + b^2 \quad (4)$$

Subtracting (3) from (4), transposing and collecting terms:

$$2(a - d)y + 2cx - c^2 - 2ad + d^2 = 2ab, \text{ or}$$

$$y = \frac{2a(b + d) + c^2 - d^2 - 2cx}{2(a - d)}$$

To simplify the work, let $\frac{2a(b + d) + c^2 - d^2}{2(a - d)} = m$, and

$$\frac{2c}{2(a - d)} = \frac{c}{a - d} = n; \text{ then } y = m - nx \quad (5)$$

Substituting in Equation (1):

$$m^2 - 2mnx + n^2x^2 + x^2 - 2cx + c^2 = b^2$$

Transposing and collecting terms:

$$(n^2 + 1)x^2 - 2(mn + c)x = b^2 - m^2 - c^2$$

from which:

$$x^2 - 2 \times \frac{mn + c}{n^2 + 1}x = \frac{b^2 - m^2 - c^2}{n^2 + 1}$$

Now let $r = \frac{mn + c}{n^2 + 1}$, and $s = \frac{b^2 - m^2 - c^2}{n^2 + 1}$; then $x^2 - 2rx = s$. Solving this quadratic, $x = r \pm \sqrt{s + r^2}$. In application, the method is very simple: first calculate the values of m and n; then calculate r and s; finally, calculate x, and substitute in Formula (5) to get y. In practice, it will be found that it will be necessary to use the minus sign in the double sign before the radical when finding x. While this solution may look somewhat complicated, it is in reality very simple, as will be seen when actual values are substituted. J. J.

BENDING I-BEAMS

H. D. M.—Are the I-beams used in road graders, etc., bent in the bulldozer, or are they drawn through special rolls? So far, we have had no success with the bulldozing process, as the flange on the inside of the curve refuses to upset, and therefore leaves the beam somewhat crooked, as shown by the dotted lines in Fig. 1.

Answered by John S. Myers, Philadelphia, Pa.

It is generally realized that the compression side of a member being bent does not upset as much as the tension side

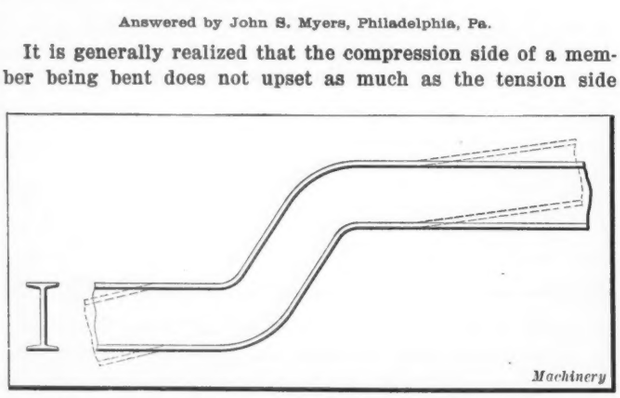


Fig. 1. Desired and Actual Results obtained with Bulldozing Process

elongates, but the reason is perhaps not so well understood. If a body A, Fig. 2, is compressed between two surfaces B and C, it spreads out in the direction of the arrows D. Such a body is under an apparent compressive stress equal to the force with which the acting members B and C are pressed together. It is, however, also under a tensile stress acting in the direction of arrows D, the intensity of which is a stress that will produce a deformation in this direction equal to that produced in the same direction by the compressive force. Now, when a body is bent under the action of dies,

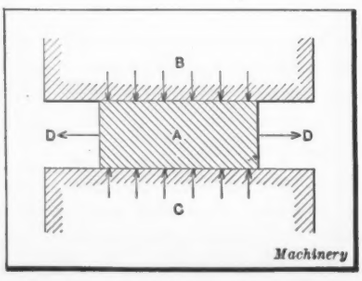


Fig. 2. Forces produced when compressing a Member

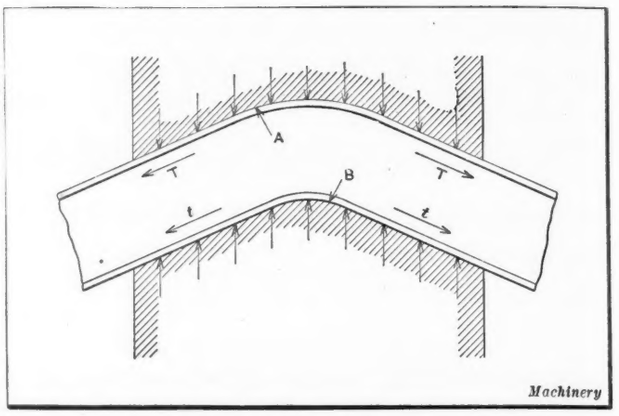


Fig. 3. Forces produced when bending a Body in Dies

the pressure of the dies acts on both sides of the member being bent and induces a tensile stress in the member as mentioned. This acts in direction T, Fig. 3, on the tension side, adding to the tension produced by the bending action; but on the compression flange B, it acts in the direction indicated by arrows t and opposes the upsetting of the compression flange. Another reason that the compression flange B does not upset as much as the tension flange A elongates is illustrated by Fig. 4. Here the dies in coming together bear upon the tension flange

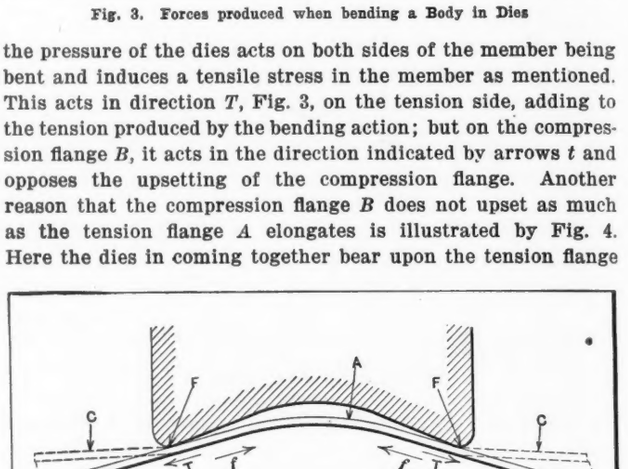


Fig. 4. Influence of Friction on Bending

A at points F and bear upon the compression flange B at point F_1. The pressure applied on flange B at F_1 induces tensile forces, acting as at t, opposing the upsetting of the compression flange. The forces acting at F induce tensile stresses acting in the direction T, assisting the elongation of this flange; but the friction of the points F opposes motion with a force as indicated at f. This frictional resistance f and the extra elongation due to the forces t tend to bend the member as indicated by the dotted lines C. A suggested method of

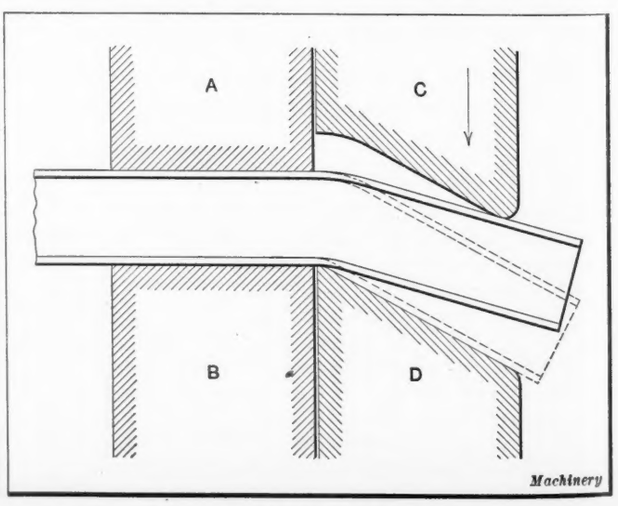


Fig. 5. Suggested Form of Bending Dies

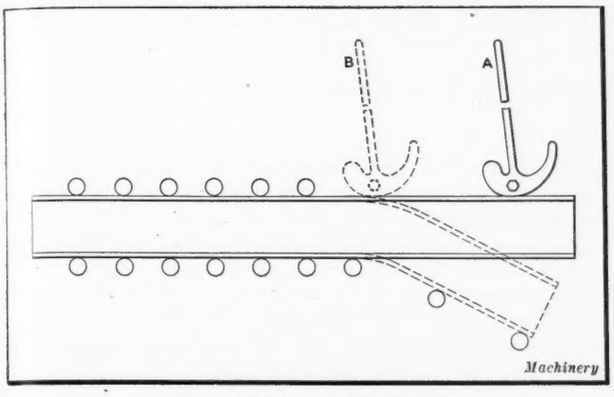


Fig. 6. Method of bending by Hand

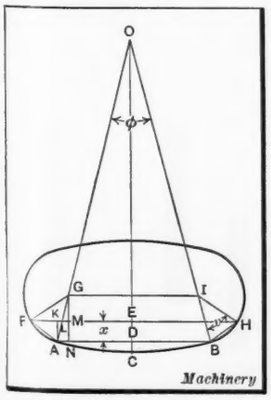
overcoming this tendency is indicated in Fig. 5. Here the dies *A* and *B* clamp the beam and the dies *C* and *D* do the bending. When bending by hand on the bending floor, the preliminary bend is generally made by applying the force at some little distance from the actual point of bend, as at *A*, Fig. 6, and the bend is brought to the line more closely with the force applied nearer to the bend, as at *B*. This method is more natural and brings the member to the desired shape more readily; but even then it squirms out of shape and is afterward bent cold to correct the errors. This subsequent operation is called "fairing" among shipbuilders. In general, if a fairing operation is to be avoided, the peculiarities of the problem are to be noted and modifications of the bending dies made to rectify the errors.

DEPTH OF TANK PARTLY FILLED

J. F. F.—The illustration shows an oval tank that is 30 inches long. Radius *OA* is 20 inches, radius *GA*, 3 inches, and chord *AB*, 10 inches. What will be the depth *EC* when the tank is horizontal and contains 231 cubic inches of liquid?

A.—The area $FHBCAF = 231 \div 30 = 7.7$ square inches and is made up of two equal segments *FA* and *BH*, the segment *ACB*, and the trapezoid *FABH*. Denote the angle *AOB* by ϕ, angle $FGA = BIH$ by v, and distance *ED* by x. Sin $\frac{\phi}{2} = \frac{5}{20} = 0.25$; whence $\frac{\phi}{2} = 0.25268$, and $\phi = 0.50536$. Area of segment $ACB = \frac{20^2}{2}(\phi - \sin\phi) = 4.24752$ square inches.

Therefore, area $FHBAF = 7.7 - 4.24752 = 3.45248$ square inches. Draw *AK* perpendicular to *FH*. Angle $FAK = FAL - KAL = FAL - \frac{\phi}{2}$, and $FAL = \frac{\pi}{2} - \frac{v}{2}$; hence, $FAK = \frac{\pi}{2} - \frac{v}{2} - \frac{\phi}{2} = 1.5708 - 0.25268 - \frac{v}{2} = 1.31812 - \frac{v}{2}$.



Finding Depth of Liquid in an Oval Tank

$FK = x \tan FAK = x \tan\left(1.31812 - \frac{v}{2}\right)$,

and area of trapezoid $FABH = \left(\frac{FH + AB}{2}\right)x = \left[10 + x\tan\left(1.31812 - \frac{v}{2}\right)\right]x$

Area segment $FA = \frac{3^2}{2}(v - \sin v)$, and area of segments *FA* and $BH = 9(v - \sin v)$; hence, area $FHBAF = \left[10 + x\tan\left(1.31812 - \frac{v}{2}\right)\right]x + 9(v - \sin v) = 3.45248$. Or,

$$f(v) = \left[10 + x\tan\left(1.31812 - \frac{v}{2}\right)\right]x + 9(v - \sin v) - 3.45248 = 0 \quad (1)$$

This equation contains two unknown quantities x and v, and it is necessary to express x in terms of v. Draw *GN* perpendicular to *AB*; it will be also perpendicular to *FH*, which is parallel to *AB*. Since $AGN = \frac{\phi}{2}$, $GM = 3\cos\frac{\phi}{2} - x = 2.90474 - x$. Angle $GFM = \frac{\pi}{2} - \left(v + \frac{\phi}{2}\right) = 1.31812 - v$, $GM = 3\sin(1.31812 - v) = 2.90474 - x$. Solving for x:

$$x = 2.90474 - 3\sin(1.31812 - v) \quad (2)$$

The procedure now is to assume a value for v, substitute it in Equation (2) and find x, and then substitute these values of x and v in Equation (1). To find a tentative value for v, note that x must be less than $3.45248 \div 10 = 0.345248$; call it 0.34; then, $0.34 = 3\sin(1.31812 - v)$, from which $v = 0.292$, approximately. Substituting this value of v in Equation (2), $x = 0.33884$. Substituting these values of v and x in Equation (1), $f(v) = 0.24563$. Trying 0.282 for v, $f(v) = 0.06704$; and for $v = 0.272$, $f(v) = -0.10766$. Tabulating these values and using the second difference,

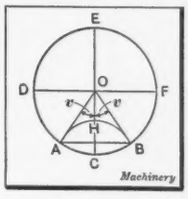
v	$f(v)$		
0.272	−0.10766		
		17470	
0.282	0.06704		389
		17859	
0.292	0.24563		

$v = 0.27820$ when $f(v) = 0$. $DC = 20 - \left(20\cos\frac{\phi}{2}\right) = 0.63508$; for $v = 0.27820$, $x = 0.31763$, from Equation (2). Therefore, $EC = x + DC = 0.31763 + 0.63508 = 0.95271$ inch.

J. J.

GIVEN AREA OF LUNE TO FIND RADIUS

H. E. L.—Referring to the accompanying illustration, please show how to find the radius $AC = CH$, which must be such that the area of the lune *AHBC* shall be equal to one-tenth the area of the circle *ADEFB*.



Finding Radius of a Lune

A.—Let R = radius *OA*, x = radius *CA*, and v = angle $AOC = 1/2\ AOB$.

Area of segment $ACB = R^2(v - 1/2\sin 2v)$ (1)

$$x = 2R\sin\frac{v}{2} \quad (2)$$

Since angle $ACE = 1/2(\pi - v)$,

Area of segment $AHB = \frac{x^2}{2}[(\pi - v) - \sin(\pi - v)]$

$$= 2R^2\sin^2\frac{v}{2}(\pi - v - \sin v) \quad (3)$$

Adding Equations (1) and (3),

Area of lune $AHBC = R^2[v - 1/2\sin 2v + 2\sin^2\frac{v}{2}(\pi - v - \sin v)]$ (4)

But $1/2\sin 2v = \sin v\cos v$ and $2\sin^2\frac{v}{2} = 1 - \cos v$.

Substituting these values in Equation (4), and reducing,

Area $AHBC = R^2[\pi - \sin v - (\pi - v)\cos v] = 1/10 \times \pi R^2$ (5)

Equation (5) reduces to:

$$f(v) = \sin v + (\pi - v)\cos v - 9/10 \times \pi = \sin v + \pi\cos v - v\cos v - 9/10 \times \pi = 0 \quad (6)$$

Now, substituting in Equation (6) the first three terms of the sine series and the cosine series for $\sin v$ and $\cos v$,

$$v - \frac{v^3}{6} + \frac{v^5}{120} + \pi - \frac{\pi v^2}{2} + \frac{\pi v^4}{24} - v + \frac{v^3}{2} - \frac{v^5}{24} - \frac{9\pi}{10} = 0$$

Clearing of fractions, combining, reducing, and letting $\pi = 3.1416$,

$$v^5 - 3.927v^4 - 10v^3 + 47.124v^2 - 9.4248 = 0 \quad (7)$$

Solving Equation (7), $v = 0.4761$. Substituting this value of v in Equation (6), $f(v) = -0.00005$; substituting 0.4760 for v, $f(v) = 0.00006$; hence, $v = 4760 + 6/11 \times 1 = 4760.54 + = 0.476054$, after restoring the decimal point. Substituting this value of v in Equation (2),

$$x = 2R\sin\frac{0.476054}{2} = 0.47158R$$

If a table giving the angles in radians is not available, it will be necessary to express v in degrees, minutes, and seconds before interpolating in the table of trigonometric functions; the writer used radians for the foregoing calculations. J. J.

PRACTICAL FEATURES OF FACTORY LIGHTING[1]

PRINCIPAL REQUIREMENTS OF ARTIFICIAL LIGHTING

BY C. E. CLEWELL[2]

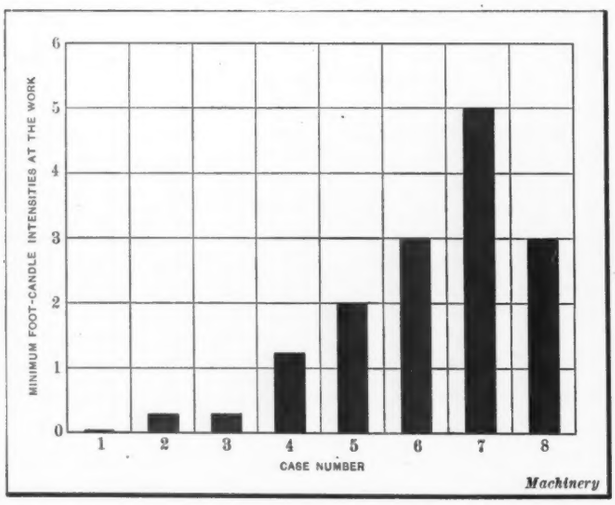


Fig. 1. Minimum Values of Illumination at the Work. The Case Numbers are the Same as those used in Table 2

IT is proposed in this article to outline the requirements of proper artificial lighting for factory spaces and to indicate some of the ways in which these requirements can be met with modern lamps. It is well to note at the outset of this discussion that there are two parts to the general problem of factory lighting, one of which relates to the source of light, that is to say, the lamps of the system, and the other to the general question of the effect of the lamps in illuminating the objects to be seen and thereby in fulfilling the conditions for clear vision. These two parts of the lighting problem may be briefly summarized as cause and effect, and, as we shall show, each of these involves careful determination if the net result is to be satisfactory. One of the major objects of this article is to show that the problem of lighting, as it is looked upon today, is a scientific one, and that every factory should make it a point to see that the two fundamental qualities, which may be termed a maximum in the excellence of the system and a minimum in the cost, are realized in the lighting equipment chosen. In other words, it will be shown that the lamps for a factory section should no longer be merely a matter of haphazard selection without regard to their cost and lighting efficiency, nor that the arrangement of the lamps should be determined on the basis of guesswork or random judgment.

Principal Requirements

In the article "Daylight Facilities in Industrial Plants," published in the November number, is shown a greater need for artificial light in the average factory than is commonly supposed. It is not only necessary to have an adequate supply of artificial light for those who comprise the night force, but it is also necessary to provide artificial lighting during a portion of the day, as practically every winter day has two dark intervals, namely, in the early morning and at the close of the working day, and unless artificial light is available these intervals are likely to form a relatively non-productive part of the day's work. To these, there must be added other dark intervals due to cloudy or stormy weather conditions and to fogs or a smoky atmosphere, all of which go to make the artificial lighting problem of more than ordinary importance in the fall and winter, and also of considerable importance in the spring and summer months.

In order to meet these dark conditions, it follows that every factory should have a general system of artificial illumination with a sufficient intensity at all parts of the floor space, first of all, to make it possible for employes to get around their machinery and to use the aisles and passages without risk of accidents, and, second, to enable materials to be handled easily as well as the ordinary operations that confront a workman outside of the actual work in hand. This initial requirement means that a certain fairly well defined degree of general illumination is a necessity without regard to the working operations themselves, but, of course, in addition to this there must also be available a sufficient degree of illumination at the work to make it possible for the operative to see clearly all the details of his work without undue tax on his vision. While the latter intensity is naturally higher than that usually specified for aisles and passages, it is entirely practicable to make the general illumination adequate not only for the prevention of accidents, but also for the work itself, with a somewhat lower intensity for aisles and passages and such spaces as storage and the like.

The foregoing points constitute the principal requirements of the lighting system from the standpoint of its effect in illuminating the work. To these there must be added a number of important points concerned with the lighting equipment. First, and possibly most important, is the use of proper shades or reflectors in connection with the lamps for the purpose of directing the light from the lamps most advantageously to the working surfaces beneath. This statement implies that the lamps are mounted overhead near the ceiling and that they are distributed symmetrically over the ceiling area so that the illumination can be made practically uniform over the entire floor space. However, it may be noted that even where the lamps are located fairly close to the machinery in the form of individual units for each workman, they should likewise be supplied with suitable auxiliaries for directing the light to the space where it is required. There is another important reason for the use of reflectors or shades, namely, to serve as a protection for the eyes of those employes who may have occasion now and then to look into or toward a lamp, thus

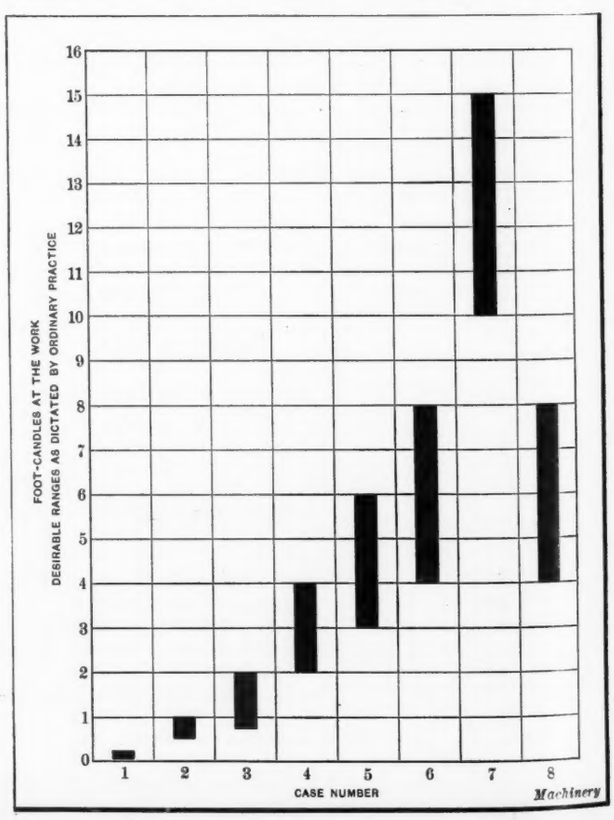


Fig. 2. Ranges in Values of Illumination at the Work. The Case Numbers may be identified by Reference to Table 2

[1] For other articles on this subject, see "Daylight Facilities in Industrial Plants," in the November number of MACHINERY.

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TABLE 1. DESIRABLE AND MINIMUM INTENSITIES OF ILLUMINATION TO BE MAINTAINED AT THE WORK AS STIPULATED IN THE FACTORY LIGHTING CODE ISSUED IN 1915 BY THE ILLUMINATING ENGINEERING SOCIETY AND REVISED IN JUNE 1917

Classification	Foot-candles at the Work	
	Ordinary Practice	Minimum
(a) Roadways and yard thoroughfares	0.05 to 0.25	0.02
(b) Storage spaces	0.50 to 1.00	0.25
(c) Stairways, passageways, aisles	0.75 to 2.00	0.25
(d) Rough manufacturing, such as rough machining, rough assembling, rough bench work	2.00 to 4.00	1.25
(e) Rough manufacturing involving closer discrimination of detail	3.00 to 6.00	2.00
(f) Fine manufacturing, such as fine lathe work, pattern-making and toolmaking, light-colored textiles	4.00 to 8.00	3.00
(g) Special cases of fine work, such as watch-making, engraving, drafting, dark-colored textiles	10.00 to 15.00	5.00
(h) Office work, such as accounting, typewriting, etc.	4.00 to 8.00	3.00

Machinery

receiving the total light in their eyes. If the lamp is very bright, as is the case, for example, with tungsten lamps, when one looks directly at the bare filament of the lamp, the glare not only produces a most unpleasant blinding effect, but if such abuse of the eyes is long continued, that is, day after day, permanent injury may result. A suitable reflector may be used with such lamps not only to increase the downward light and thus raise the efficiency of the system, but also to serve as a medium for softening the light and reducing the objectionable glare and blinding effect otherwise present.

The lighting equipment should be supplied from circuits or mains which are so planned out, both as to size and arrangement, that there may be an adequate pressure at the lamps at all times. This follows at once when it is considered that only slight changes in the supply pressure (the voltage in the case of electric lamps) cause considerable changes in the amount of light given off by the lamps. Hence, if such voltage changes are rapid, due possibly to changing loads taken by motors on the same circuits, an unpleasant flicker of the light will result; whereas, at times of heavy load, for example, when all the lamps in the factory are turned on, if there is an undue steady decrease in the supply circuit voltage, then a part or all of the lamps will burn dim and the resulting illumination may prove inadequate and unsatisfactory. The supply circuits, however, should not only be capable of maintaining a steady pressure, but they should also be so protected that an interruption of the service is unlikely. In other words, dependence is placed on the circuits for a steady and reliable supply at all times, and these requirements are also apparently related closely to the machinery in the power plant which, coupled with the circuits, largely determines the reliability of the lighting service.

TABLE 2. CLASSIFICATION OF WORK AS OUTLINED IN THE REVISED CODE OF FACTORY LIGHTING OF THE ILLUMINATING ENGINEERING SOCIETY

No.	Classification	Examples
1	Yards	Roadways Thoroughfares
2	Storage	Storage spaces in general
3	Stairs	Stairways Passageways Aisles
4	Rough manufacturing	Rough machining Rough assembling Rough bench work
5	Rough manufacturing	Involving closer discrimination of detail
6	Fine manufacturing	Fine lathe work Patternmaking Toolmaking Light-colored textiles
7	Special cases of fine work	Watch-making Engraving Drafting Dark-colored textiles
8	Office work	Accounting Typewriting

Note: The numbers used in this table correspond with the numbers in Figs. 1 and 2.

Rules—Old and New

The average person who is confronted with the problem of deciding on the way in which to light a factory naturally desires to have available rules for his guidance. In earlier practice, one method of specifying the lamps for electric lighting was in terms of watts per square foot of floor space required to produce enough light for the given conditions. Thus we might say that the lamps for a system of a certain type, to be satisfactory for a given floor area, must be installed in such density over the ceiling area as to result in a value of, say, 1.25 watt per square foot of floor space. For a floor area of 800 square feet, then, it would be necessary to install an aggregate of 800 × 1.25, or 1000 watts, so that eight lamps, each consuming 100 watts, would meet the requirements.

A rule of this kind has certain clearly defined disadvantages, and to make these disadvantages understood it is only necessary to point to the kind of errors that can easily be made in attempting to apply it to any given case. One instance that came to the writer's attention about eight years ago will serve as a good example. At that time tungsten lamps were coming into use for factory lighting, and Nernst lamps were also quite generally used for certain purposes. The electrical man in a factory had been told that if a figure of 1.25 watt per square foot of floor was used, good office lighting would result. The same person was later requested by the works department to plan out the lighting for an office where Nernst lamps were to be used. He applied the figure of 1.25 watt per square foot, which had been given him for tungsten lamps, for the determination of the number of Nernst lamps required, and when the system was installed the illumination was found to be inadequate—approximately one-half of what it should have been—and, as a result, an entire rearrangement was necessary. The explanation of the discrepancy in this case is found to be due to the difference in the amount of light given off by the two types of lamps per watt of energy consumed. Thus the Nernst lamps produced only about one-half as much light for each watt as the tungsten units, and, as a result, the total number of watts calculated on the basis of the constant 1.25 (for tungsten lamps) produced an effect only one-half as great as it should have been. In other words, a higher constant of about 2.5 should have been applied for the Nernst lamps for satisfactory illumination. This simple yet

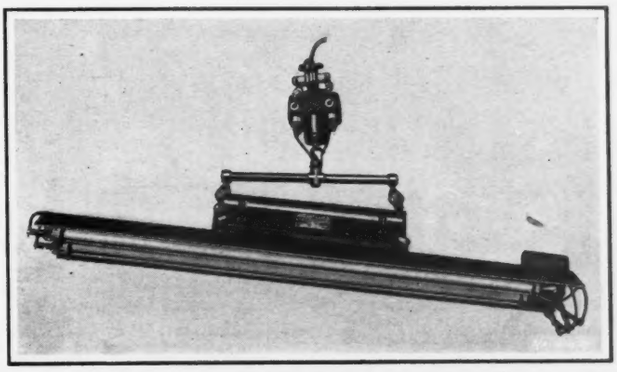

Fig. 3. New PP Lamp of Mercury Vapor Type

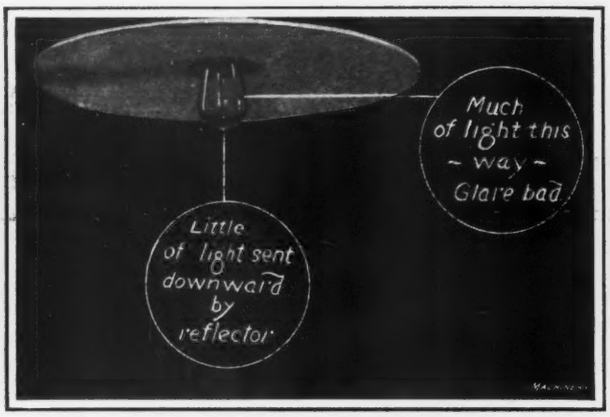

Fig. 4. Tungsten Lamp equipped with Flat Glass Reflector. Note that Much of the Light can pass off in Horizontal Directions, thus wasting Light and causing Objectionable Glare

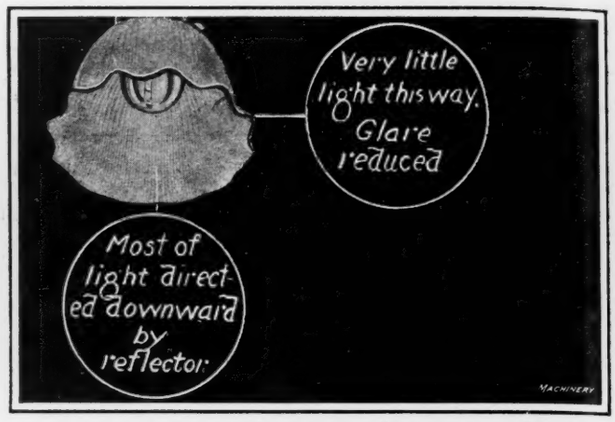

Fig. 5. Tungsten Lamp with Holophane Bowl-shaped Prismatic Glass Reflector. Note that Most of the Light is directed downward by the Prisms that constitute the Reflector

important illustration will serve to show that a rule of this kind is not satisfactory, primarily because it concerns itself with the power consumed by the lamp rather than with the effect of the light from the lamp in producing illumination on the work. This very weakness of earlier lighting rules has led in more recent years to the beginning of a movement on the part of certain authorities to adopt a form of specification of the quantity of light necessary at the work for various industrial operations and to work back from this specification to find the number and size of the lamps that are required.

Fig. 6. Large Tungsten Incandescent Lamp housed in Metal Reflector and suspended by Automatic Disconnecting Hanger

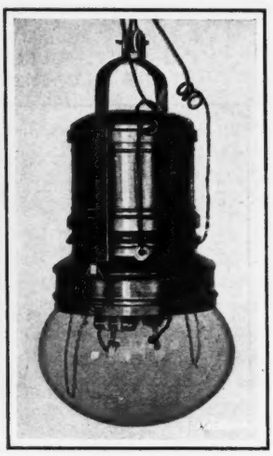

Fig. 7. Quartz Mercury Vapor Lamp for High Interiors and for Exterior Lighting

Without going into details of the theory involved in this more recent method, it may be outlined briefly by saying that if we multiply the intensity of the illumination at the work by the area of the floor space to be lighted, the product of these two factors gives us a measure of the total light required over the entire working surface. Dividing this product by the efficiency with which the light from the lamps is sent to the work indicates directly the amount of light that all the lamps must generate. The result of this operation is expressed in a unit called the "lumen," which is now commonly used by the lamp manufacturers to indicate the amount of light produced by a given lamp. A simple example of this more recent rule will serve to show the method and will make clear the meaning of the two or three steps in the process. Suppose for a given class of work that an intensity of 5 foot-candles (the unit of illumination intensity was described in the article "Daylight Facilities in Industrial Plants," in the November number) is required at the work, and that the area of the floor or working surface to be lighted is 4000 square feet. Multiplying these two factors, we have: $5 \times 4000 = 20{,}000$ lumens, which is the quantity of light that must be incident or at the working surface. If now we divide this total light at the work by an assumed efficiency of, say, 50 per cent, which means merely that of the total light generated by the lamps 50 per cent is effective at the work while the remainder is lost or dissipated in various way, the result indicates the total amount of light that must be produced by all the lamps, or $20{,}000 \div 0.50 = 40{,}000$ lumens. The remainder of the problem is merely to decide on the size of lamp to be used, and if each lamp produces, according to the manufacturer's rating, a value of, say, 1000 lumens, we know at once that 40 lamps distributed over the ceiling area will produce the required result. The application of this rule depends on the proper choice of intensity and on a careful selection of the efficiency constant, as the latter depends on the type of reflector and on the surrounding conditions, whether light colored or dark, and also to some extent on the arrangement of the lamps and the size of the lighting system.

As a guide to this first factor of intensity, Table 1 shows the recent recommendations of the committee on

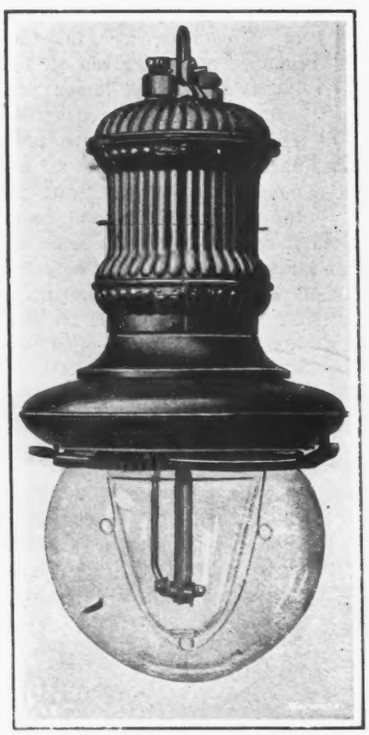

Fig. 8. Flame Carbon Arc Lamp which can be used so as to produce White or Yellow Light

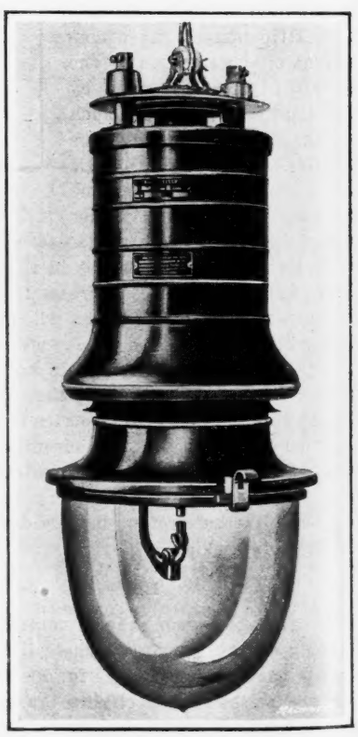

Fig. 9. Metallic Flame Arc Lamp Suitable for Lighting Large Yard Areas connected with Factory Buildings

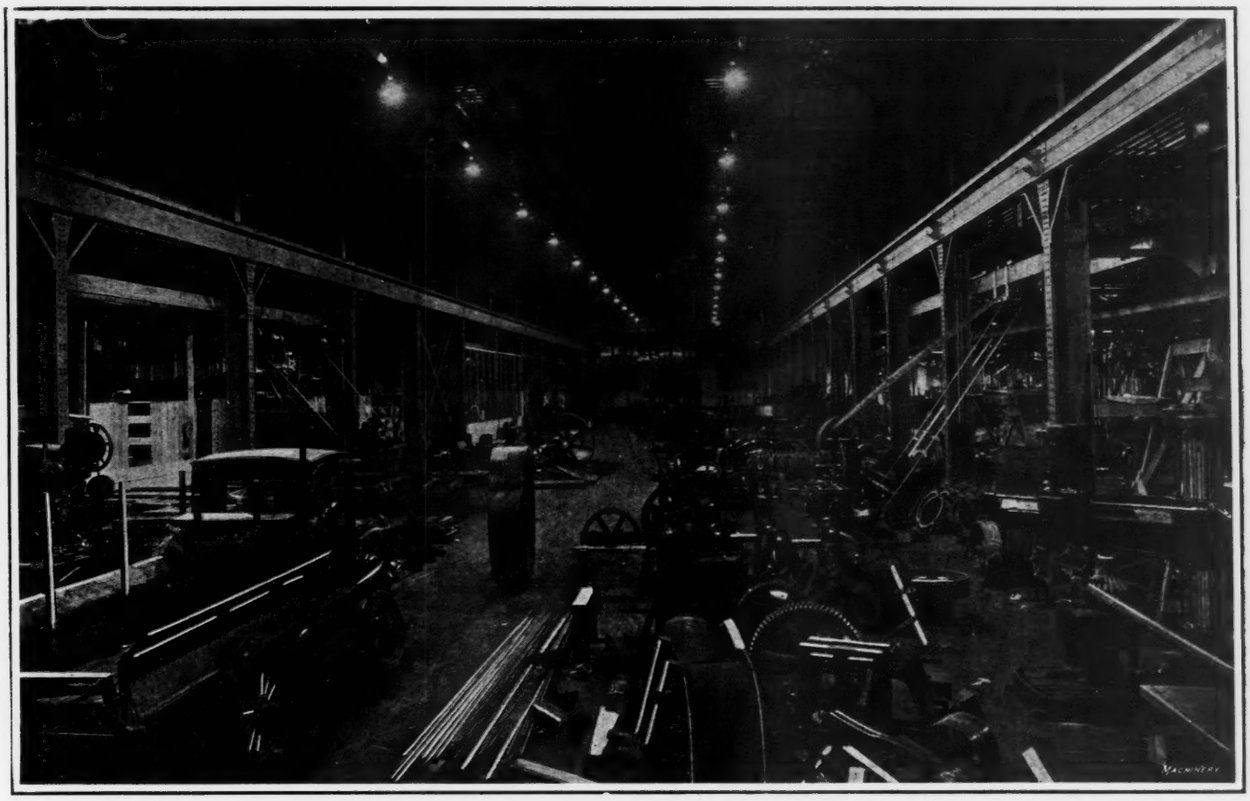

Fig. 10. Interior of Machine Shop Space where Uniform Illumination is produced on Work by Tungsten Lamps and Efficient Reflectors with Lamps well overhead

lighting legislation of the Illuminating Engineering Society for various classes of work, while Table 2 gives the divisions that have been employed in classifying the spaces and operations in a number of typical industries. Figs. 1 and 2 show graphically the minimum values of the illumination intensity and the ranges dictated by ordinary practice for each given class of work. The industrial commissions of several states have adopted tables of this same nature.

The values of the efficiency factor (commonly called the utilization efficiency) used in various practical cases is somewhat more difficult to determine. The writer has found that values of about 30 per cent apply to average industrial conditions with the usual dark surroundings due to dirt on walls and ceilings and where due account is taken of the gradual deterioration of any system due to the unavoidable gathering of dust and dirt on the lamps and reflectors. Certain lamp

Fig. 11. Large Foundry Space illuminated by Overhead System of Lamps. Note Excellent Distribution of Light on Working Surfaces, Little Glare being produced on Eyes of Employes in looking up and down Aisles because Lamps are so High

manufacturers publish values ranging from somewhat below 30 per cent for some types of reflectors and small installations up to 71 per cent in large installations and presumably with more or less ideal surroundings. As a general policy it will be found desirable in factory lighting work to be conservative in the selection of this constant and to use smaller rather than too high values, because too high a value means that not enough light will be produced at the work, whereas a conservative value means that some allowance has been made for the accumulation of dirt on the equipment between the times regularly assigned for cleaning.

Fig. 13. Example of Flood Lighting by Lamps equipped with Efficient Projectors and mounted on Adjacent Structures

Lamps Available

The discussion thus far has related mainly to ways for accomplishing given results. This feature is obviously an important one to the practical shop man who may be entrusted with this division of the factory equipment. Of almost equal importance is the question of the kinds of lamps that are available for producing the results. It is not generally recognized, perhaps, that great limitations were imposed in earlier lighting practice by a lack of a suitable range of lamp sizes. For example, until ten or fifteen years ago, practically the only types of electric lamps in use or available for factory lighting were the arc lamps, of rather bulky size and unsuited to many conditions, and the carbon filament glow lamp, which was mostly employed in the form of a hand lamp on an extension cord or possibly as a drop lamp located close to the bench or machine. These two extremes left much to be desired in earlier practice, since many factory spaces could not be effectively illuminated by either type. Today new and improved types of lamps are available.

Lamps are rendered more efficient by the use of properly designed shades or reflectors, and this important feature is well illustrated by Figs. 4 and 5; from Fig. 4 it will be seen that the bare tungsten lamp or the same lamp equipped merely with a flat glass shade makes it possible for much of the light to pass off in horizontal directions from the lamp. Fig. 5, by way of contrast, shows a similar lamp equipped with a superior reflector which has the property of sending the light of the lamp effectively to the work and at the same time of protecting the eyes of workmen from the blinding glare of the bare lamp filament. Figs. 3, 6, 7, 8 and 9 illustrate various types of modern electric lamps, each type being suited, in a general way, to given conditions of service. The two types that are most widely used for shop and factory interiors are the mercury vapor and the tungsten lamps illustrated in Figs. 3 and 6. The lamp shown in Fig. 3 operates on direct-current circuits and is designed mainly for high areas. It consumes 770 watts at 220 volts. Other types for use on alternating-current circuits are also available. The lamp in Fig. 8 gives off 920 mean lower hemispherical candlepower and consumes 500 watts. It is occasionally used for very high interiors. The lamp in Fig. 9 gives off a mean lower hemispherical candlepower of 495 with an energy consumption of 272 watts. The lamp in Fig. 7 produces a very high candlepower with a low energy consumption. This type is not on the market at present, because of the inability of the manufacturers to secure quartz tubing from abroad.

Systems and Special Cases

As a final consideration, brief mention should be made of the general systems of illumination that have come to be looked upon as standard for factory work. It may be stated at the outset that the use of individual lamps close to the work is discouraged as inferior to the scheme of general lighting illustrated in Figs. 10 and 11, where the lamps are shown mounted well overhead according to a symmetrical arrangement. Sometimes a modified form of general lighting is found desirable in which the positions of the lamps, instead of being symmetrical throughout, are determined by the locations of the machines on the floor space. Such a plan embodies some of the features of the local or individual method of lighting along with the advantages that usually accompany the placing of the lamps well overhead. Other interesting and important schemes involve the use of enclosing bowls for sending some or all of the light of the lamps to the ceiling, from which it is redirected to the working surfaces beneath. Such schemes, one of which is shown in Fig. 12, depend for successful operation on light colored ceilings and surroundings generally, and hence their use is limited largely to the office or drafting room. One feature which is of unusual value at this time is the use of projectors with tungsten lamps for illuminating building fronts or yards at night as a protective feature. Such a case is illustrated in Fig. 13, where it will be noted that the projectors are so mounted that the front and sides of the building are brightly illuminated.

Fig. 12. Interior of Large Office where Indirect System of Illumination with Tungsten Lamps is used. Note Uniform Distribution of Light on Working Surfaces and Freedom from Glare because Lamps are concealed from View

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

IN THIS NUMBER

Craley "Master Toolmaker." Craley Mfg. Co., Lancaster, Pa. 357
Crawford Fifteen-Inch Engine Lathe. Joseph Crawford, Jr., Co., Erie, Pa. 358
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T. P. Walls Multiple Saw and Beveling Table. T. P. Walls Tool Co., Inc., 75 Walker St., New York City. 369

CRALEY "MASTER TOOLMAKER"

FOR use in drilling holes in jigs, fixtures and other work where accurate spacing is required, the Craley Mfg. Co., Lancaster, Pa., has developed a machine known as the "master toolmaker," which is illustrated and described herewith. This equipment is clamped to the table of a drilling machine with the drill bushing in line with the axis of the machine spindle, so that holes may be drilled as in the case of an ordinary jig. The "master toolmaker" is equipped with a compound table with slides at right angles, which are operated by the usual screw and ball crank combination. These screws are merely employed for making approximate settings; the actual locations which are depended upon to secure accurate spacing of the holes are made by means of micrometer heads and standard distance bars. The work-table is adjusted until both micrometers read zero against stops on the table which act as the micrometer anvils, and in this position the center of the drill bushing is located over the intersection of the guide strips on the work-table. Work is clamped against these guides, and in starting to locate the first hole, the two table slides are manipulated so that an approximate setting is secured, after which the distance bars and micrometer heads are used to obtain the final location in the manner to which reference has already been made. In this connection, attention is called to the fact that the arm which supports the drill bushing should be set to bring the bushing as close to the work as possible. Obviously it is possible to use this equipment to locate any number of holes in the work in the desired relation to each other, as the table slides may be manipulated and final settings made with the micrometer heads and distance bars, so that each hole is located in the proper relation to the preceding hole. Clamps are provided to lock the table in each position before the drilling operation is started.

It will be apparent from the illustrations that the distance bars are supported by bushings held in V-shaped seats, which support them at the proper height to line up properly between the micrometer spindles and stops on the table which come in contact with the micrometer spindles when the table is set in the zero position. A set of distance bars is provided, so that any desired combination of whole inches may be obtained up to the full capacity of the machine, and thousandths of an inch are then secured with the micrometer heads. Johannson gages may be used in place of the distance bars, if so desired. An important feature is that by the use of this machine there is no danger of introducing a cumulative error, as each measurement is taken from the intersection of the guide strips. The capacity of the machine is for holes up to $\frac{5}{8}$ inch in diameter, but should it happen that the necessity arises for drilling a hole of larger size, this can easily be done by drilling and reaming a smaller hole in the desired location; then, after all other holes have been drilled and reamed, a plug is placed in the hole, which marks the position at which the larger hole is to be drilled. The work is next transferred to

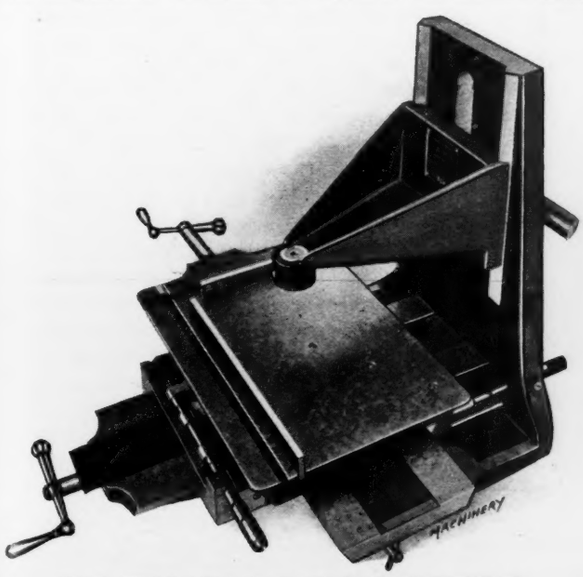


Fig. 1. "Master Toolmaker" built by the Craley Mfg. Co.

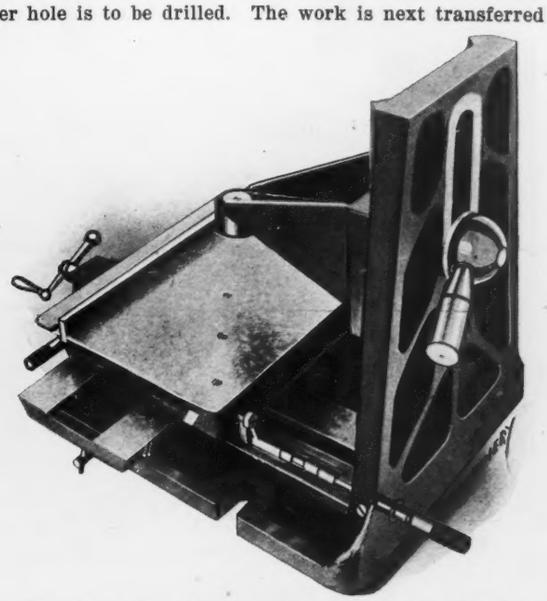


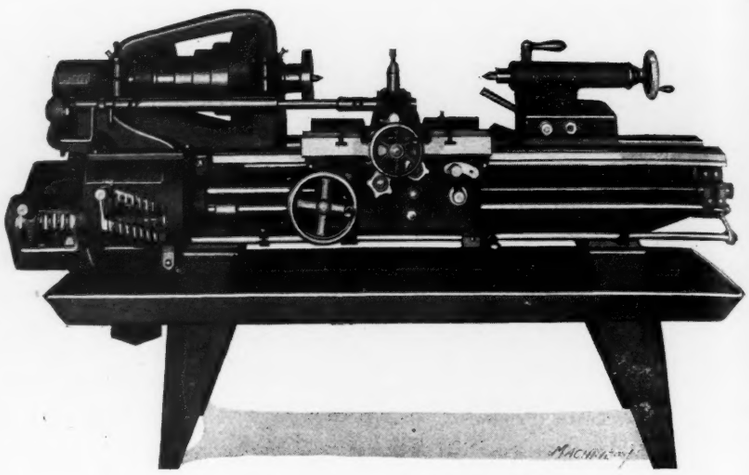
Fig. 2. Rear View of Machine, showing Clamp for Bushing Arm

a lathe and indicated by means of this plug; then, after the desired location has been secured, the hole can be bored and reamed on the lathe. The advantage of using a machine of this type in shops where there is a lot of accurate drilling to be done will be obvious to any experienced mechanic, and it is claimed that in such shops the machine will pay for itself in a relatively short time.

Among the classes of work in which holes may be drilled and reamed with the "master toolmaker," the following may be mentioned: jigs, dies, templets, master plates, models, etc. Its use does away with the necessity of laying out work, and the accuracy of the "master" may be depended upon without requiring a high-priced mechanic to spend a lot of time on inspection. The work-table is 8 by 11 inches in size, and it has a maximum longitudinal movement of 8¼ inches, a maximum transverse movement of 6¼ inches, and the drill bushing arm has a maximum vertical movement of 6 inches. The machine weighs approximately 125 pounds. The regular equipment furnished includes two special Brown & Sharpe micrometer heads, eleven hardened and lapped distance bars 1/4 inch in diameter and varying in length in intervals of 1 inch, eight bushings from 3/16 to 5/8 inch in diameter, inclusive, varying by intervals of 1/16 inch, and four clamps and screws for the T-slots.

CRAWFORD FIFTEEN-INCH ENGINE LATHE

The Joseph Crawford, Jr., Co., Erie, Pa., is manufacturing the improved design of fifteen-inch lathe shown in the illustration. This lathe differs from the design previously built in regard to the arrangement of the gear- and feed-boxes and in the separation of the screw-cutting mechanism from the feeding mechanism. This machine also has an increased range of feeds and a larger thread-cutting capacity. The bed of this lathe has three large vees and one flat way. The spindle is made of high-carbon steel and has a 1¼-inch hole extending through it. The tailstock is so arranged that the compound rest can be set at right angles to the cross-slide. The longitudinal and cross feeds are friction driven and the cross-feed screw is provided with micrometer adjustment. By changing

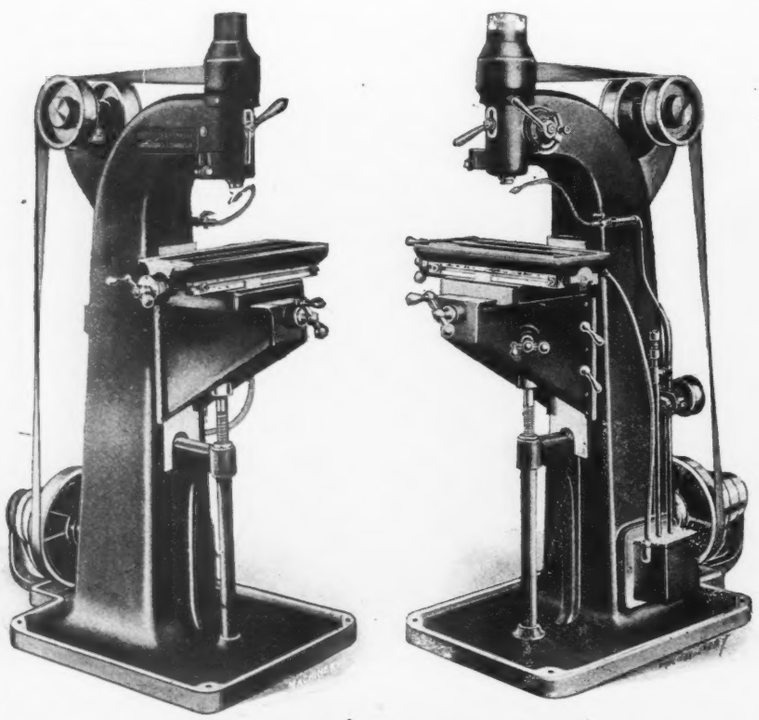


Crawford Fifteen-inch Engine Lathe

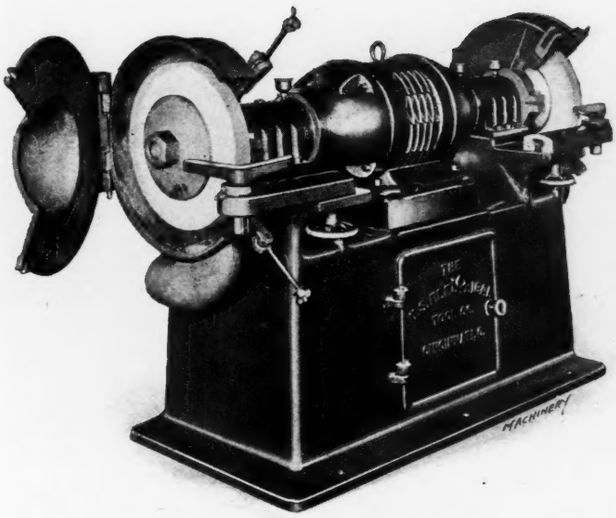
the positions of the two handles (see illustration) forty-eight different speeds can be obtained for threading and feeding. There is an independent feed-rod, so that the lead-screw can be used exclusively for thread cutting. The taper attachment is of simple design and so connected to the back of the carriage that it is within easy reach of the operator. The spiral relieving attachment, which is shown in position in the illustration, may be used for straight or taper parts and for inside or outside relieving on both right- and left-hand work with any number of flutes from 2 to 28, inclusive. A universal joint and a bearing block will be provided when axial relieving is desired. The taper attachment and relieving attachment are part of the special equipment. This lathe swings 16½ inches over the ways and 9½ inches over the carriage. The maximum distance between the centers is 34 inches. The machine has a thread-cutting capacity varying from 2 to 120 threads per inch.

TAYLOR & FENN VERTICAL-SPINDLE MILLING MACHINE

The Taylor & Fenn Co., Hartford, Conn., is now manufacturing a vertical-spindle milling machine designed for light vertical milling operations. This machine, as shown in the accompanying illustrations, is sufficiently rigid and powerful to permit of high cutter speeds and may be adapted for light profiling work. The machine is equipped throughout with double-row self-aligning ball bearings. The unit system of construction is followed throughout, the individual parts being assembled in groups. The spindle is mounted in a steel sleeve in the head, which has a vertical movement of two inches, controlled by a hand-lever at the side of the head. The spindle is locked in position by a clamp ring and handle seen at the front of the head. Positive stops are provided for regulating the depth of the cut, and there are adjustable stops for controlling the longitudinal and cross movements of the table. A four-step cone pulley, in conjunction with a two-step friction countershaft, provides eight spindle speeds, ranging from 246 to 4000 revolutions per minute. The machine table has a longitudinal movement of 11 inches, a cross movement of 6 inches and a vertical movement of 9½ inches. The maximum distance from the end of the spindle to the top of the table is 11½ inches, and the center of the spindle is 10 inches from the column. The table has a working surface 6 by 18 inches. The standard equipment includes a geared pump with tank and piping complete.



Taylor & Fenn Vertical-spindle Milling Machine



Grinder made by United States Electrical Tool Co.

UNITED STATES ELECTRICALLY DRIVEN GRINDER

The electrically driven grinder illustrated herewith is an addition to the line of grinding machines made by the United States Electrical Tool Co., 6th Ave. and Mt. Hope St., Cincinnati, Ohio. This type of grinder may be equipped with either a 5-horsepower motor and two 18- by 3-inch wheels, or with a 7½-horsepower motor and two 24- by 4-inch wheels. These grinders are fitted with ball bearings, instead of using phosphor-bronze or babbitt metal. The grinder of 5-horsepower capacity has a Westinghouse Type CS motor, having a speed of 1120 revolutions per minute. The grinding wheel guards are made of steel and can be furnished with or without exhaust connections. These machines can also be equipped with a push-button switch for starting and stopping the motor, if desired.

"DEMCO" SENSITIVE DRILLING MACHINES

The De Mooy Machine Co., 706 Frankfort Ave., N.W., Cleveland, Ohio, has added to its line of drilling machines three high-speed ball bearing machines, which are known as Nos. 30, 31 and 32. It will be apparent from the illustrations that the Nos. 30 and 31 machines are of essentially the same design, except that one is of the bench type while the other is furnished with a pedestal base, so that it can be set up on the floor. The No. 32 machine is of practically the same design as the No. 31, except that the former is adapted for a maximum speed of 12,000 revolutions per minute, while the latter machine can be run up to 3500 revolutions per minute. On all machines provision is made for adjusting the position of the idler pulley at the back of the machine to provide compensation for the belt when it is shifted from one step on the cone pulley to another. This is done by means of a rack and pinion operated by a capstan wheel, which results in sliding the bracket on which the idler pulley is carried. In addition to the sliding movement, this idler pulley bracket is supported on a pivot, so that a compression spring of the proper strength may be employed to give the desired belt tension. Another distinctive feature of the design is that an independent sleeve is provided which may be clamped in the desired position by tightening the two binding levers seen at the front of the machine. This sleeve affords adequate protection for the spindle bearings, etc., against damage from grit and other foreign matter; and the vertical position of the sleeve may be adjusted so that it affords the maximum amount of support for the spindle at the exact position in which it is working.

On the Nos. 30 and 31 machines, the spindle is 7/16 inch in diameter, and on the No. 32 machine the spindle is 11/16 inch in diameter. The principal dimensions of all the machines are as follows: distance from center of spindle to column in gap of the machine, 8 inches; distance from center of spindle to planed surface of column, 7¼ inches; maximum traverse of spindle, 8 inches; maximum traverse of feed rack, 4 inches; maximum traverse of table, 15 inches; width of belt for spindle drive, 1 inch; number of spindle speeds, 5; width of oil-groove around table, 1¾ inch. In addition to the single-spindle machines shown in the accompanying illustrations, these machines are built in one-, two-, three-, four- and six-spindle gangs.

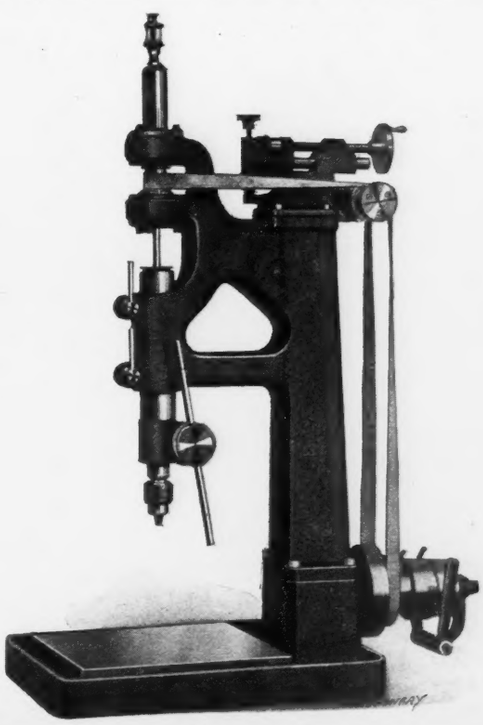


Fig. 1. No. 30 "Demco" Bench Type High-speed Sensitive Drilling Machine

WESTINGHOUSE DRUM REVERSE SWITCH

One of the latest products of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., is a small drum reverse switch for operating motors in machine tool, wood-working and other services requiring reversing of the motors. The small size of this reverse switch makes it especially adapted for mounting directly on the machine. A terminal board of heavy micarta forms the back of the switch, and on the front side of this board are mounted the stationary contacts. The movable contacts are mounted on cast-brass brackets clamped on the shaft, from which they are thoroughly insulated. Good contact is insured by phosphor-bronze springs, on the movable contacts, these being protected by copper shunts. Heavy barriers of asbestos lumber separate adjacent sets of contacts, so that cross-arcing is impossible. All live parts are protected from exposure by an enclosing cover of sheet steel, lined with asbestos, and held in place by two ring latches, which permit easy removal for inspection or renewal of contacts.

These switches are made for alternating-current or direct-current circuits. For alternating-current service

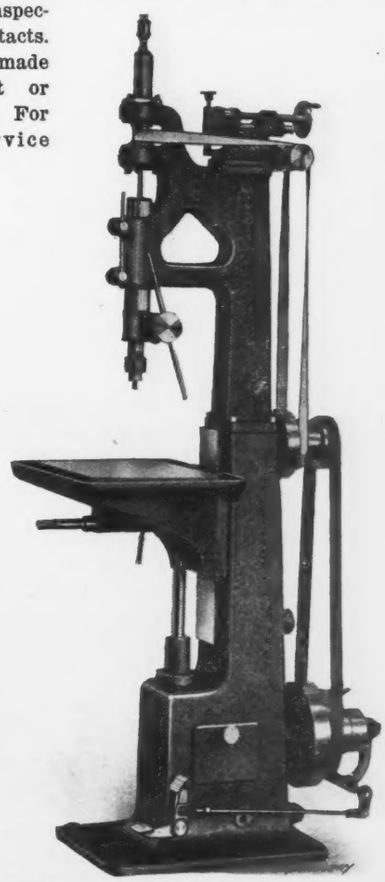
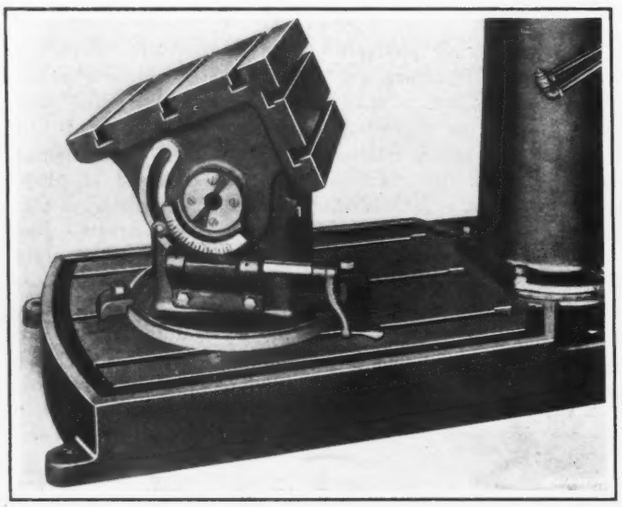


Fig. 2. No. 31 "Demco" Floor Type High-speed Sensitive Drilling Machine

and for direct-current service without dynamic braking, they are provided with "Forward," "Off" and "Reverse" positions. For alternating-current service, the motor is connected directly across the line. For direct-current applications with dynamic braking, the switch handles have five positions, as follows: "Forward," "Drift," "Off and Brake," "Drift," and "Reverse." They may be used with automatic starters for shunt- and compound-wound motors. With compound-wound motors having heavy series winding for tailstock and cross-rail service, they may be used to connect the motor directly to the line, either with or without resistors permanently connected in series with the armature. When remote mechanical control is desirable, both alternating-current and direct-current switches can be furnished with extended shaft, permitting either gear or sprocket operation.

MORRIS UNIVERSAL TILTING TABLE

For use in connection with its line of radial drilling machines, the Morris Machine Tool Co., Court and Harriet Sts., Cincinnati, Ohio, is building a universal tilting table, which is illustrated in position on the base of a radial drilling machine. This table can be furnished in place of the regular box table and is so designed that it can be tilted to any angle by means of a worm and worm-wheel segment graduated in degrees. In addition to being tilted to any angle, the table can be swiveled around and clamped in any desired position. When brought to the straight position it rests on positive stops. The working surface of the top of this table is 18 by 18 inches, and the side is 11 by 18 inches. The T-slots are ¾ inch in width.



Universal Tilting Table for Radial Drilling Machines built by Morris Machine Tool Co.

CLEVELAND MILLING MACHINE VISE

A plain milling machine vise made by the Cleveland Milling Machine Co., 18511 Euclid Ave., Cleveland, Ohio, is shown in Figs. 1 and 2. This vise is made as low as possible without sacrificing strength and the facilities for clamping. It has a machine-finished flange extending completely around it, so it can be placed in any position on the machine table. The jaws are of steel and can be removed readily if special jaws are required. The ways of the vise are solid and the block and gibs are so arranged that they wipe the ways free from chips and foreign matter. The tongue slots are milled at right angles to each other, so that the vise can be held either parallel or at right angles to the machine spindle. The tongue slots on all vises are the same distance from the face of the solid jaw. This facilitates using the vise in place of a fixture. The solid jaw and the opposite end, in which the screw bearing is formed, are cored out as shown in Fig. 2. The object of coring out these sections, instead of making them solid, is to secure an even distribution of metal and a stronger construction by eliminating spongy metal at these points and shrinkage strains. The movable jaw is gibbed on the outside, so that there are no slots cut in the base of the vise. These external gibs, however, do not interfere in any way with the clamping of the vise onto the milling machine table.

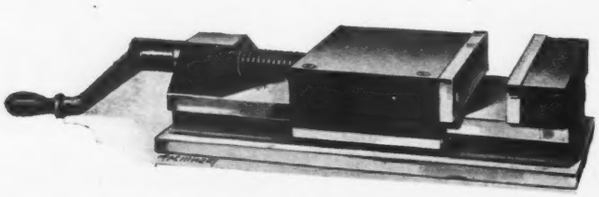


Fig. 1. Cleveland Plain Vise for Milling Machines

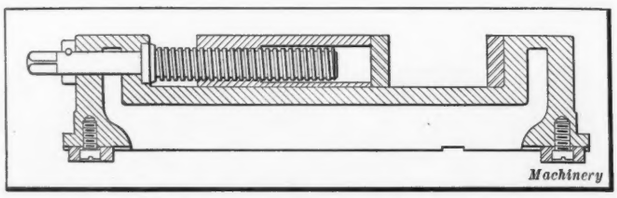
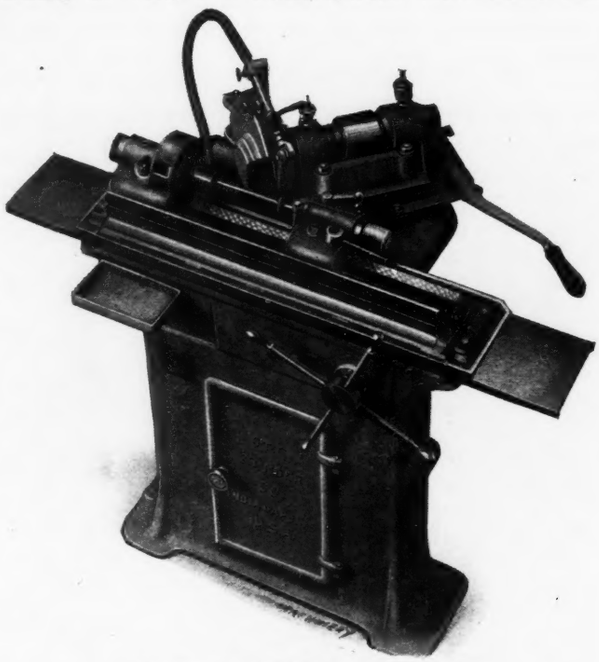


Fig. 2. Sectional View of Cleveland Vise

OTT VALVE SEAT GRINDING MACHINE

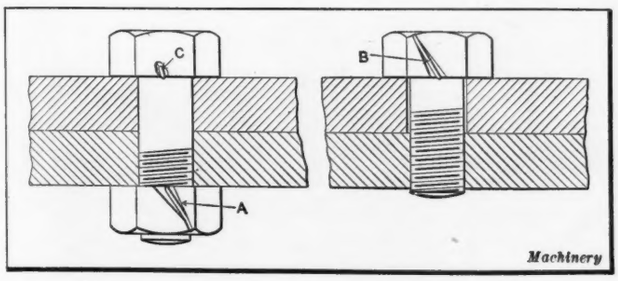
The Ott Grinder Co., Indianapolis, Ind., is now building a machine that is especially adapted for grinding motor valve seats—usually to an angle of 45 degrees. A special wheel-base provided on this machine can be set so that work may be ground to any angle from 15 to 60 degrees. It will be apparent from the illustration that the wheel-slide is operated by a hand-lever to provide for traversing the wheel across the face of the work while it is being ground; the table reverse is also operated by hand turnstile levers. When centers are not provided in the head of the valve stems, a draw-in collet chuck is furnished, which may be operated by a treadle to facilitate handling the work, as a treadle-operated chuck leaves both of the operator's hands free. This provision made for rapid handling of the work, together with means of traversing a straight-faced wheel across the valve seat, insures the rapid production of accurate work.



Valve Seat Grinder built by Ott Grinder Co.

BOLT AND NUT LOCKING DEVICE

The nut and bolt locking device described in the following is intended primarily to provide a simple and inexpensive but effective method of preventing the unscrewing of nuts or bolts. After a nut is placed on a bolt, it is held in position by a spring locking member *A* (see accompanying illustration). One



Zeman Bolt and Nut Locking Device

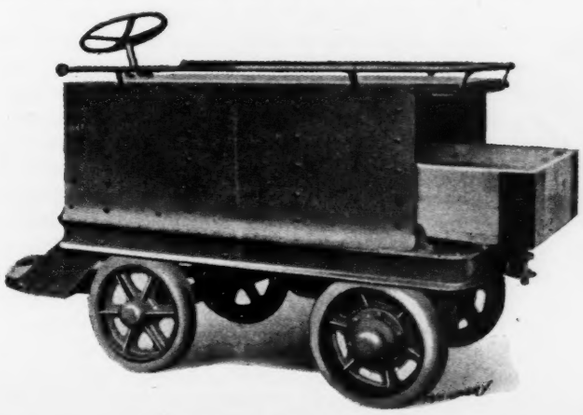
end of this flexible spring is secured in the narrow end of a V-shaped recess formed in one side of the nut. This recess is wide enough on the bearing side of the nut to allow the flexible locking member *A* a certain amount of movement, and this spring is of such a length that it tends to project beyond the surface of the nut; consequently any backward movement of the nut will cause the locking spring to bend in a direction opposite to the rotation of the nut so that it "bites" into whatever part is held by the nut and the latter is prevented from unscrewing. When it is desired to remove the nut it is simply necessary to insert the point of a knife blade or other pointed instrument back of spring *A* and force it outward. The view to the right shows this same locking device applied to a cap-screw or bolt. The spring *B* in this case is inserted in a slot in the bolt-head. When the nut-locking device is employed in connection with a cap-screw or bolt having a round shank, means must be provided to prevent the rotation of the bolt. A small locking pin *C*, which projects from the under face of the bolt-head, is used to bite into the surface beneath the bolt-head, thus preventing rotation in either direction. This locking device has been brought out by Joseph F. Zeman, 15 E. Stonewall St., Charlotte, N. C., and is manufactured by the Inter-State Machine Products Co., of Rochester, N. Y.

LANSING ELECTRIC TRUCKS

Savings to be made through the substitution of power-driven equipment for manual labor in transferring materials and products through a factory are of exceptional importance at the present time, due to the scarcity of labor and the abnormally high wages which are being paid to all classes of factory employes. To facilitate the handling of loads, factory trucks are now being equipped with electric motors which obtain their power from individual storage batteries carried on the trucks. The Lansing Co., Lansing, Mich, builds three types of load carriers, which comprise a truck, a tractor and a trailer. The truck and the tractor are power-driven, the truck being used for ordinary classes of transfer work, while the tractor is employed to pull a train of trailers loaded with materials or products in course of manufacture.

Two types of tractors are made, which have rated trailer load capacities of 5000 and 12,000 pounds, respectively. The tractor carries no load itself, but is essentially a small electric locomotive. Both the tractor and trailers are of sufficiently narrow gage so that they can be run in factory aisles wherever hand trucks may be used. Two types of steering apparatus are used, one of which is controlled by a wheel and the other by a lever. The operator's platform and seat are so placed that the driver may either stand or sit. Where the steering wheel is used, the operator has the wheel and controller handle at his right; and with the lever-controlled steering gear, the lever is at the right and the controller handle at the left of the operator. The brake pedal is operated by the left foot.

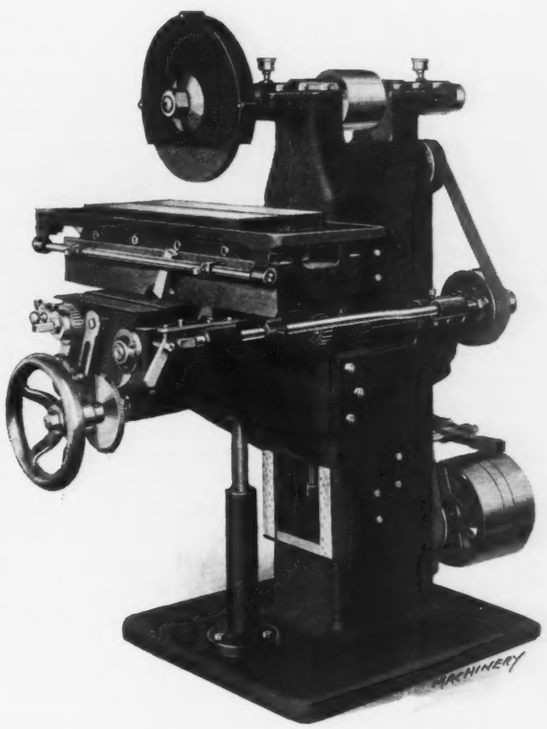
So far as the design of the mechanism is concerned, the Lansing trucks are identical with the tractors, except that the trucks are mounted on springs at the rear as well as at the front, and that the front tires are widened to take care of the increased load they must carry. The point of difference lies in the fact that the truck has a "loading area" on which the raw material or product is carried by the truck, while the tractor is simply employed to haul a load of trailers in the manner to which reference has already been made.



Electric Tractor built by the Lansing Co.

NOBLE & WESTBROOK SURFACE GRINDER

One of the recent products of the Noble & Westbrook Mfg. Co., Hartford, Conn., is the automatic surface grinder which forms the subject of the following description. All working parts of the machine are carefully designed to provide for excluding abrasive dust and other foreign matter which would cause undue wear. A thrust bearing is provided on the table raising and lowering mechanism, which provides for having this mechanism operate easily; and the usual practice is followed of graduating the feed-screw dials to read to 0.001 inch. All slides and spindle bearings are furnished with means of compensating for wear. The cross-slide is equipped with an automatic stop which limits its travel in both directions, and the platen can be instantly started or stopped by use of a hand-lever which engages or disengages the clutch in the driving pulley. This provision for stopping or starting the table without stopping the wheel-spindle or other parts of the machine is an exceptionally convenient feature. It will be apparent from the illustration that this machine is simply designed and particularly well adapted for the requirements of many manufacturing departments where surface grinding operations must be performed on the work.



Surface Grinder built by the Noble & Westbrook Mfg. Co.

At the front of the table there will be seen a horizontal bar on which the reversing stops are carried. These stops may be set in any desired position along the bar, so that they reverse

the direction of table travel in the required points. It will be seen that motion for the table traverse is taken direct from the main drive by means of an auxiliary shaft at the right-hand side of the machine, from which power is transmitted to the table through gearing. The large handwheel at the front of the machine provides for raising or lowering the table, and it will be seen that a graduated dial on the same shaft with this handwheel reads to 0.001 inch, which provides for raising the table to take a cut of the desired depth. Transverse adjustment of the table is made by a wrench placed over the end of the squared shaft, which will be seen above the handwheel. The principal dimensions of this machine are as follows: capacity of machine, 8 by 20 inches; distance between bottom of 12-inch grinding wheel and top of platen, 7 1/2 inches; diameter of spindle, 1 9/16 inch; size of grinding wheel, 12 inches in diameter by 3/4 inch face width; and size of tight and loose pulleys, 7 inches diameter by 4 inches face width. This machine can be furnished either with or without a magnetic chuck.

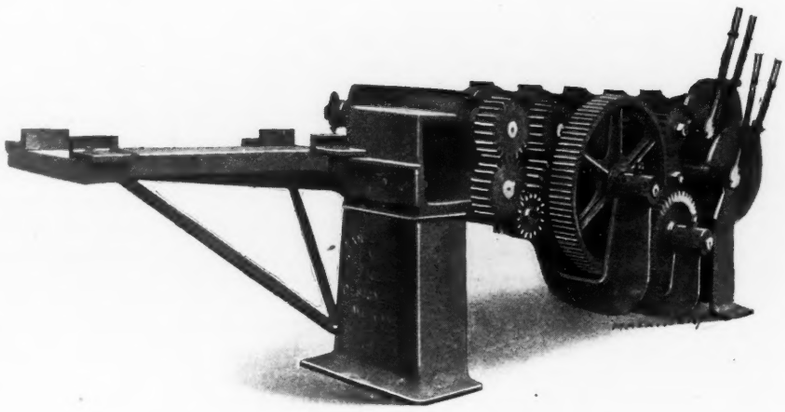


Fig. 2. Opposite Side of Kane & Roach Channeling Machine

KANE & ROACH CHANNELING MACHINE

For the formation of irregular sections of sheet metal of indefinite length for use in the manufacture of metal furniture, automobile rims, show cases, etc., in the small sizes, and for structural steel work, gutters, molds for cement forms, steel car manufacture and kindred uses in the large sizes, the process of rolling or channeling is being largely developed. Sheet stock of any metal may be formed cold by channeling, and any thickness up to ¼ inch may be worked without difficulty. The speed at which this class of work is handled varies from fifty to ninety feet per minute, according to the metal and the shape to be produced.

Generally speaking, a machine for channeling has two or more pairs of steel rolls, although when the shape is particularly intricate the number sometimes runs as high as twelve or fourteen pairs. These rolls are spaced at equal distances along the machine, and each pair gives the metal strip a bend that is slightly more pronounced than that given by the preceding pair. The rolls are geared together and are driven by connecting gears, so that each pair helps to drive the sheet forward as well as to form it. On machines built by Kane & Roach, Niagara and Shonnard Sts., Syracuse, N. Y., the rolls are always of the overhanging type, that is, the forming rolls operate on the outside of the machine housing. This permits changing them without difficulty when it is desired to produce different sections. In addition, the work is more readily reached and controlled than would be possible if the rolls were within the housings. Adjustable outer bearings are fitted to the outer ends of each pair of rolls tying the upper and lower shafts together so they cannot spring apart under the pressure.

In very heavy channeling machines, the outer shaft bearings are connected in the horizontal direction as well. The gears for driving the rolls are made of steel in order that they may have the necessary strength. The driving gear is always located as near the center of the machine as possible in order to distribute the strain on the roll gears. In view of the fact that vertical adjustment of the rolls is often necessary, the gear teeth must be cut fairly long to allow considerable latitude in meshing. The vertical adjustment is made possible by mounting the upper roll bearings in eccentric sleeves. The drive is always to the lower rolls first, in order to keep the gearing as compact and as low down on the machine as possible. In order to start the stock correctly, so that it will not start off center or on a slant, a long table or guide is provided before the first pair of rolls. The design of these parts and their functions will be touched upon later.

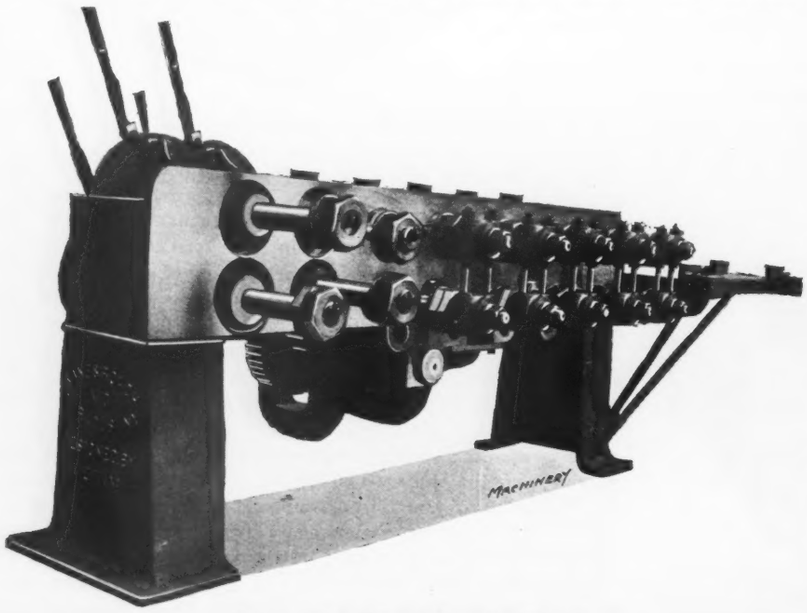


Fig. 1. Kane & Roach Channeling Machine

Rolls for Channeling

Except for the very smallest and lightest work where there are delicate shapes to be produced, the rolls for channeling machines are made from 80-point carbon steel castings. When the size and shape permit, they are cored out. The rolls are turned to the finished shape, and after hardening, are ground. In case of delicately shaped or small work, tool steel is used, which is hardened and afterward ground and shaped even more carefully than is necessary on the larger size work. The dimensions and proportions of channeling rolls cannot be laid down by any arbitrary rule, but depend on the depth of the bend and the thickness of the stock. In general, the ideal condition is to have the rolls as small as practical, still maintaining the strength necessary for mounting the rolls properly. Kane & Roach channeling machines are made standard, so that rolls for different sections may be used on the same machine.

On these machines the distances between roll centers are arbitrarily fixed; on the machines shown they are 16 to 20 inches, which would make the roll diameter about 8 or 10 inches. It should be borne in mind that the smaller the roll diameter, the less will be the grip of the rolls on the metal for driving purposes. This is an important point, as it is sometimes hard to secure a sufficient grip on the stock for driving it through the rolls, especially when the section is a different one to produce. This is especially true when it is necessary to form metal strips that have been perforated before channeling.

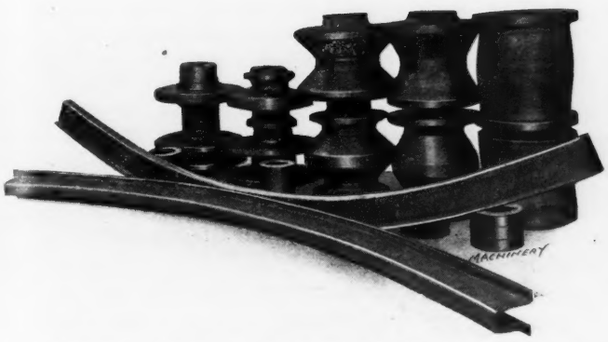


Fig. 3. Rolls used on Kane & Roach Channeling Machine and Examples of Work

In such cases the amount of metal left for the rolls to obtain the grip on is limited, and it is sometimes necessary to throw a fine sand on the stock as it is going through in order to make the rolls "take hold." Under no circumstances is a lubricant used, as it would destroy the driving power of the rolls.

Guiding the Stock

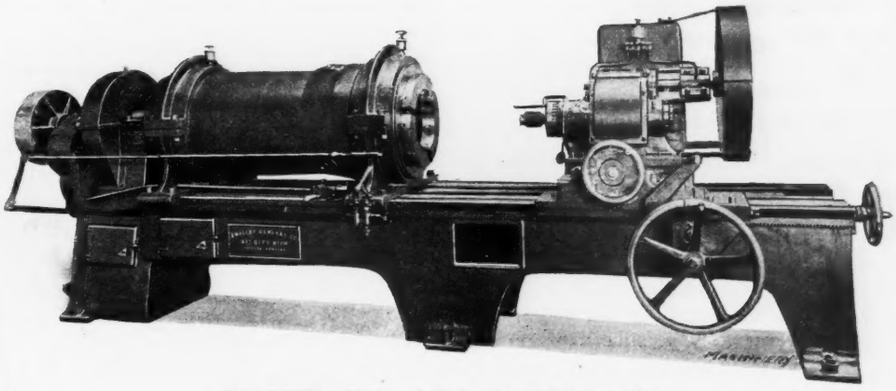
The metal to be formed by channeling must be kept under perfect control by guides before it enters the first pair of rolls and while it passes from one pair of rolls to the next; it must also be guided or straightened after it emerges from the last set of rolls, to counteract the tendency to curl. It is not necessary to have straightening rolls before the first set of rolls, as the latter are sufficient to remove any kind of irregularities from the strips, but whenever the shape to be produced can be secured without the help of the first pair of rolls, they should be used perfectly straight as feed rolls. These assist in straightening and driving the stock into the first part of forming rolls. In fact, this feature is absolutely necessary when the metal is so thick that it cannot be readily started into a pair of rolls that will give it the first slight form. It is essential to start the stock absolutely central and straight, and for this purpose a long table guide is fitted in the front of the machine. This facilitates starting the strip, and when it has once entered correctly between the first rolls, it will retain its alignment unless there is some serious defect in the channeling rolls.

Between each pair of channeling rolls, there must be means for guiding the stock to the next set of rolls, as mentioned. The usual method of doing this is to provide guides in the form of enclosed boxes in which the stock fits fairly close, which gives it the proper direction to enter the next pair of rolls. Sometimes, however, smaller rolls are used for guiding the partly channeled stock in place of the solid guides, and in addition to guiding the stock, these intermediate rolls are made to help in forming the stock as it passes through. At times, the shape of the section is such that it cannot be formed with rolls operating in one plane only; this is especially true when the section is deeply under-cut. In such cases, side rolls are employed that operate in the opposite plane. These are located in the same manner as the intermediate rolls, except that they are turned at right angles and do pressing-in operations on the sides of the stock.

It was also mentioned that, in order to produce accurate work, it is necessary to have a straightening roll at the end of the channeling machine to guide the stock as it leaves the last pair of rolls. On almost every channeling operation there is a tendency for the formed strip to curl either upward or downward, depending on the shape, as it emerges from the machine. To obviate this, a small roll, formed to fit one face of the finished stock, is fitted on the machine, following the last pair of rolls, either above or below the stock, as found necessary. When properly applied, one roll is sufficient to hold the metal straight, delivering the channeled strip in a perfectly straight condition. In the case of channeling stock for hoops or rims of any kind, it is sometimes possible to put a bending attachment on the end of the channeling machines, so that as the stock runs through the last pair of rolls it enters the bending rolls and is formed into the required circle. In this case the stock cannot be run through in indefinite lengths, but each strip must be cut to the proper length for rolling into a ring of the required diameter before it is fed to the machines.

SMALLEY-GENERAL THREAD MILLING MACHINE

The Smalley-General Co., Inc., Bay City, Mich., has added to its line of thread millers the machine which is illustrated and described herewith. This thread miller is motor-driven and equipped with separate motors on both heads with a speed variation of 4 to 1. An air collet chuck is provided which will take 14-inch armor-piercing shells, and liners may be provided for use in this collet to adapt it for holding 12-inch shells. The cutter-spindle head is composed of only two slides, this simple construction providing the exceptional rigidity which is required in a heavy-duty machine of this kind. The machine will cut threads having a pitch of ¼ inch in openings 9½ inches in diameter by 4⅞ inches long, and the complete thread-forming operation is finished in one revolution of the work. The armor-piercing shells which are to be milled are made of nickel steel which is exceptionally tough, and to provide for standing up under this service, the cutter-spindle is made of ample size and tapered as in the case of milling machine construction. The cutter-spindle is driven by large steel herringbone gears which eliminate vibration.



Thread Milling Machine built by the Smalley-General Co.

In working out the design of the feed mechanism provision has been made to enable the operator to throw in the feed at any instant without having to wait for a split nut to pick up the thread. In addition, the lead-screw on the machine is 18 inches in length, and as the wear is distributed over this long screw, ample life and accuracy are insured. Cutting compound drips down into a pan cast integral with the bed and from there runs to the tank in the base of the machine under the main head. In this tank, the oil is strained before it can find its way into the pump. All bearings except the chuck bearings are bronze bushed, and the machine is entirely controlled by a push-button control system. Two changes of speed are available, either of which may be instantly obtained. These speeds comprise a milling speed and a turning speed. On the far side of the head there is located a tool with which a finishing cut is taken on the plug seat and recess of the shell, this being done at the same chucking with the milling operation to assure obtaining true alignment and concentricity between the threads and the plug seat and recess, which is a highly important point to observe in shell manufacture.

DRAPER & HALL UNIVERSAL GRINDING MACHINE

To meet the requirements of grinding milling cutters, reamers, counterbores, taps, end-mills, gages, etc., and also for the

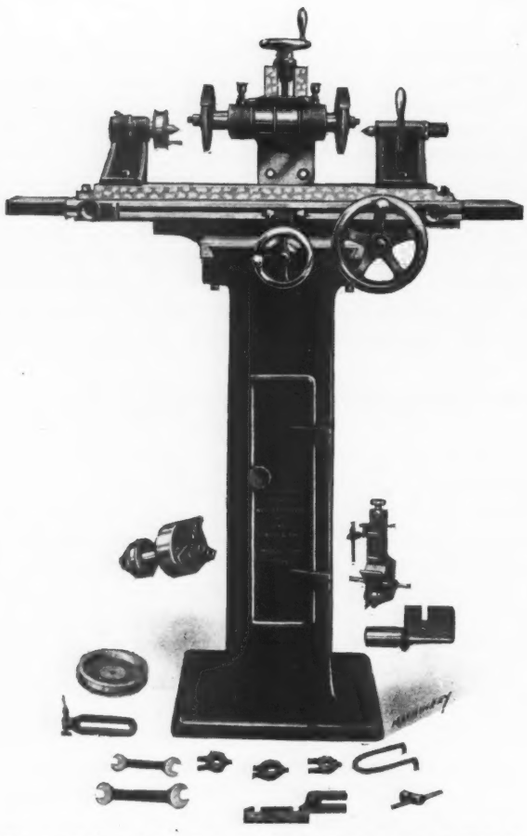


Fig. 1. Universal Grinding Machine built by Draper & Hall Co.

performance of internal and surface grinding operations, the Draper & Hall Co., Middletown, Conn., is now building a universal grinding machine which is shown in the illustrations that accompany this description. Attention is called to the fact that the internal attachment is equipped with ball bearings and is adapted for accurately grinding small work. The table is supported for its entire length by the longitudinal slide, so that there is no overhang. The slide, in turn, rests for its entire length upon the main column. The table is provided with a screw adjustment for accurately aligning the centers; and a scale at one end is graduated to set the table for grinding tapers denoted by inches of taper per foot, while the scale at the other end is graduated to indicate tapers in degrees. Dials graduated to 0.001 inch are furnished on the mechanism for the longitudinal, vertical and cross-feeds. The spindle is made of 60-point carbon steel and is carried by carefully scraped bronze bearings, which are protected against damage from abrasive dust by means of felt washers. All slides on the machine are carefully scraped and fitted with gibs.

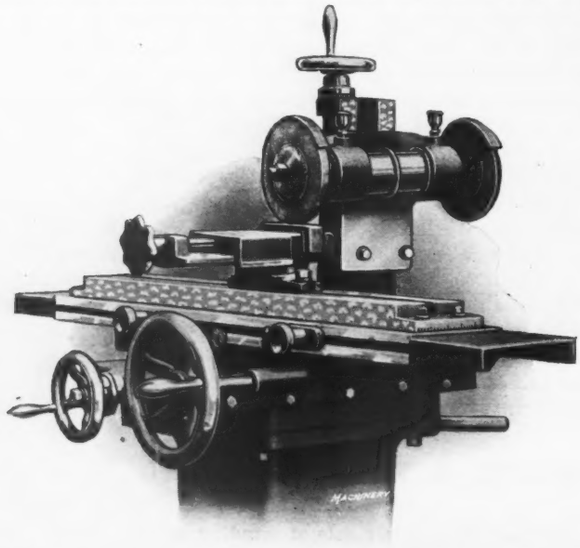


Fig. 2. Close View of Mechanism of Draper & Hall Universal Grinder

The standard equipment furnished with this machine includes a V-combination attachment, a universal vise, a three-inch chuck, an internal grinding attachment, an adjustable tooth-rest, a tooth-rest holder for spiral cutters, dogs, wrenches, etc. The principal dimensions are as follows: swing, 8 inches; maximum distance between centers, 17 inches; maximum longitudinal feed, 18 inches; maximum cross-feed, 7 inches; maximum vertical adjustment, 7 inches; size of top platen, 26 by 4 inches; size of grinding wheels used, up to 6 inches in diameter; and net weight of machine with attachments and countershaft, 700 pounds.

GARDNER VERTICAL DISK GRINDER

The Gardner Machine Co., Beloit, Wis., is now building a new vertical-spindle disk grinder which embodies several interesting features. Most conspicuous of these is the hoisting attachment, designed to handle the heavy pieces which this machine is built to grind, and also to apply and remove pressure weights used in grinding lighter castings. This attachment consists of a hand ¼-ton chain hoist, mounted on a trolley and swinging jib. A crane column, to which this jib is attached, is rigidly fixed on the base of the machine. By means of this arrangement, any heavy parts can easily be lifted from the floor and swung onto the surface of the grinding wheel.

Another feature of this machine is the dust exhaust system, which is claimed by the makers to practically eliminate the dust problem. A channel is cast into the base of the machine

Gardner Vertical-spindle Disk Grinder equipped with Individual Motor Drive

just below and around the edge of the disk wheel. Above this and just over the edge of the disk wheel is fixed a detachable guard ring, which permits the occasional removal of any coarse grindings. Attached to four openings in the bottom of the dust channel there is an exhaust manifold which connects with a powerful exhauster. This exhauster is driven from an extra pulley on the driving shaft of the machine, and in this way the grinding surface of the machine is left entirely clear, yet the dust is simply and effectively removed.

A valuable change in the construction of this machine is that by which it is made adaptable to direct-connected motor drive. In the belt-driven type, the countershaft, or outer portion of the driving shaft which carries the tight and loose pulleys, is connected to the driving shaft proper by a flange coupling. By removing this countershaft and the outer bearing, a motor may be mounted on a plate bolted to the subbase, as shown in the illustration. The rotor shaft of the

motor is connected to the driving shaft by means of a flexible coupling. Thus the necessity of mounting the motor on a side bracket and driving the shaft through sprockets and chain is eliminated. The direct connection with the driving shaft does away with all lost motion and friction incident to the old type, reduces the number of wearing parts, and produces a more compact and efficient machine. Also, the interchangeable feature may appeal to those who contemplate a change to motor-driven machinery at some future time.

The design and construction of this machine have been worked out to make it adaptable for heavy grinding operations. The 53-inch disk wheel is carried on a spindle 3⅝ inches in diameter, and supported by a heavy cast-iron flange 20 inches in diameter by 1⅜ inch thick. The spindle is mounted in two self-aligning radial ball bearings, and the end thrust is taken on an exceptionally heavy thrust bearing, the balls of which are 1⅛ inch in diameter; in fact, this equipment has been made ball bearing throughout, which represents another change from the old type, insuring smooth running qualities and a marked saving in power. The spindle has a speed of 500 revolutions per minute and is driven by means of a pair of hardened steel bevel gears, having a ratio of 2.4 to 1. These gears are enclosed in a dust-protected housing, and provision is made for ample lubrication. The entire weight of this equipment is 4600 pounds.

OAKLEY UNIVERSAL GRINDER

In the July, 1917, number of MACHINERY, a description was published of a No. 2 cutter and tool grinder which had just been placed upon the market at that time by the Oakley Machine Tool Co., Cincinnati, Ohio. Recently, this firm has added to its lines the machines shown in Figs. 1 and 2, which are of similar design except that Fig. 1 shows a machine equipped with longitudinal power feed and a wet grinding attachment, while in Fig. 2 the machine is simply equipped with the longitudinal power feed.

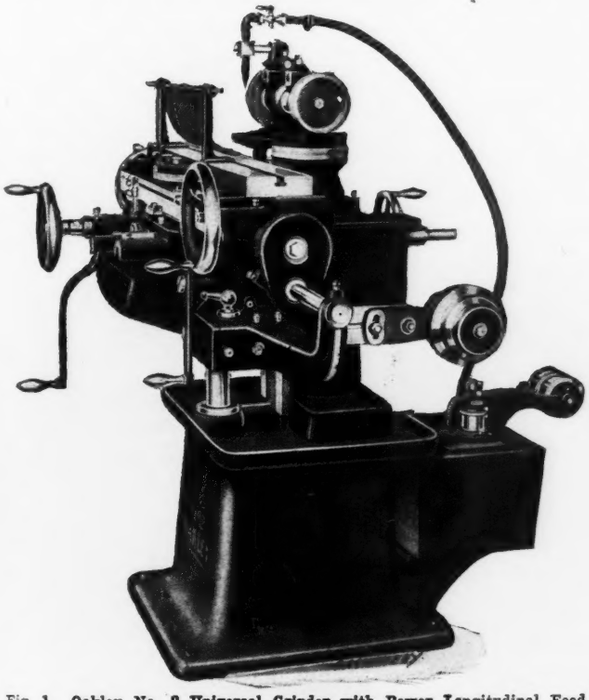


Fig. 1. Oakley No. 2 Universal Grinder with Power Longitudinal Feed and Wet Grinding Attachment

The advantage secured through the use of power feed is a smooth and even travel of the table, which increases the speed at which grinding operations can be performed. A small handle at the front of the machine controls the power feed, and the drive is through the table feed-screw, which provides an exceptionally smooth and uniform table travel. To enable the wheel to grind clean at shoulders on the work, a short "pause" of the table is allowed before reversal takes place. The reverse mechanism is positive and accurate in operation. Provision is made for operating the machine by hand by simply disengaging the clutch. Three rates of power feed are provided, which are 6, 10½ and 18 inches per minute. The stop-dogs are hinged, making it easy for the operator to run the work past the setting to measure both external and internal diameters.

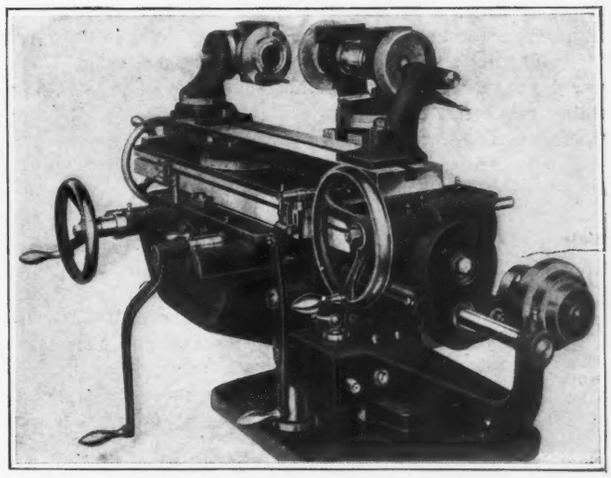


Fig. 2. Oakley No. 2 Universal Grinder with Power Longitudinal Feed

For rapid grinding of tools, and especially carbon tools, it is often desirable to be able to deliver water to the wheel and work. This is indispensable where an exceptionally fine finish is desired; and to meet the requirements of wet grinding operations, the Oakley grinder may be furnished with a wet grinding attachment which may be applied in a few minutes to any machine. The provision of power longitudinal feed and a wet grinding attachment does not alter the capacity of the machine, which is the same as that of the machine with hand feed, namely, longitudinal movement, 17 inches; vertical movement, 10½ inches; and cross movement, 9 inches. All parts are easily accessible and no extra countershaft is required. Machines of this type may be furnished with either plain or universal equipment.

TAYLOR ELECTRIC WELDER

Fig. 1 shows an electric welding machine which has recently been developed by the Taylor Welder Co., Warren, Ohio,

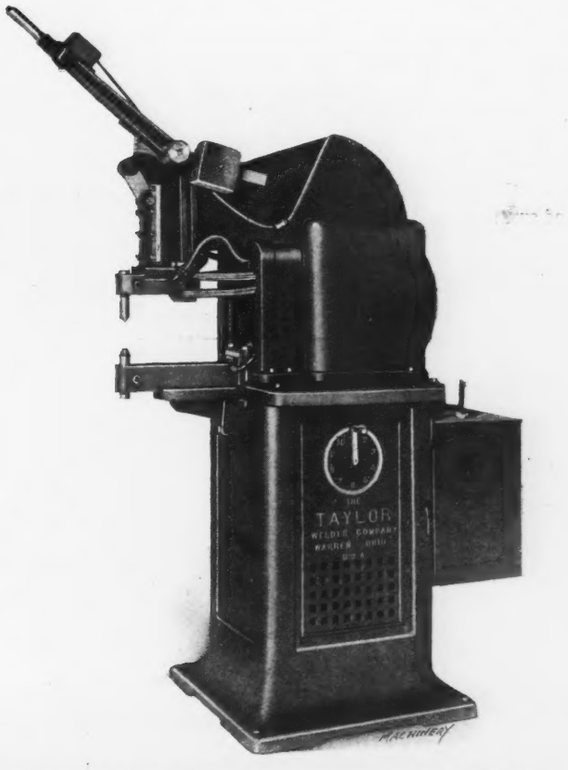


Fig. 1. Electric Spot-welding Machine built by Taylor Welder Co.

and Fig. 2 shows diagrammatically the principle upon which this machine operates. The diagram represents the electrodes or welding dies as seen from the front of the machine. The lower horn and the upper point holder, together with the welding electrodes themselves, are split and a suitable insulating material placed between each piece. The secondary leads from the transformer are likewise separated and cross where the connection is made to the lower horn, causing the current to be crossed over the path on crossed and intersecting lines as illustrated by dotted lines. It is claimed that a weld so produced is stronger and also made in a shorter space of time than has heretofore been possible. The use of the electric welder for welding material above ¼ inch in thickness has heretofore been a comparatively slow and doubtful operation in that the electrode, being of copper, requires frequent dressing due to the fact that the pressure which it is always necessary to apply to set the work together properly, causes these parts to "mushroom" or flatten out, and the time spent to redress them oftens offsets the saving which would have been shown over the old riveting method.

By means of the new process it is possible to spot-weld much heavier material than has been practicable heretofore. This is due to the fact that the electrodes may be separated and steel pressure dies used between them, and two or more separate currents of larger volume may be passed in bias directions through the metal and through each other's path; then when the metal has reached a welding temperature additional pressure may be applied with the steel dies to complete the weld. All this is done without subjecting the copper electrodes to pressure beyond the need of a good electrical contact. In other words, the electrodes are used only to carry the current and not to sustain a heavy pressure required to force the plates together to complete the weld. Another feature which makes this process unique is that it can be arranged to operate on multiphase current without unbalancing the line. This is a very important feature, as all other spot-welding machines are required to be operated on a single-phase current, and when operated on a multiphase current have a tendency to unbalance the line, which is very objectionable when the generator is of small capacity or the lines heavily loaded.

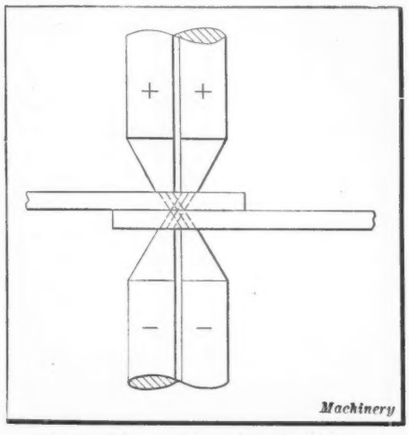


Fig. 2. Diagram illustrating Principle on which Taylor Welder operates

SIMMONS MAGNETIC CHUCKS

The Taft-Peirce Mfg. Co., Woonsocket, R. I., is now manufacturing and selling a line of rotary and reciprocating or so-called "surface" magnetic chucks, which are shown in the accompanying illustrations. These are known as the "Simmons" magnetic chucks. A feature of all of these chucks is the way in which the faceplate has been designed to provide for holding very small parts at any point on the working surface. There is only a strip of non-magnetic spacing material one-eighth inch in width between poles of opposite polarity, and in addition to extending between the poles, this non-magnetic spacing material runs all the way around the working surface of the chuck. So well has this result been carried out that a piece of work the size of a twenty-five-cent piece can be dropped in any position with assurance that a sufficient part of it will lie over the poles of opposite polarity to be sure of having the work held firmly by the chuck. Both the frame of the faceplate and the body of the chuck are non-polarized, and there are no dead spots in the face.

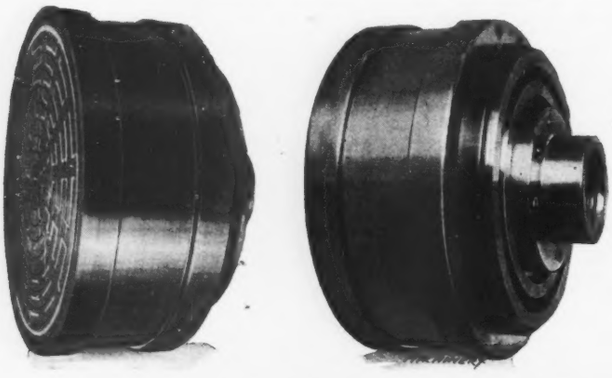


Fig. 1. Two Views of Simmons Rotary Magnetic Chuck made by Taft-Peirce Mfg. Co.

Fig. 2. Simmons Reciprocating or So-called "Surface" Magnetic Chuck made by Taft-Peirce Mfg. Co.

An important feature of the Simmons magnetic chucks is the care which has been taken in designing the switch, which is both watertight and fool-proof. All contact points are enclosed, so that the operator cannot get an electric shock, and having the contacts enclosed also makes it possible to pile up chips level with the top of the chuck without any danger of producing a short circuit. A single movement of the switch lever provides for first reversing the polarity of the chuck and then breaking the electric circuit. This effectually demagnetizes the chuck, so that no trouble is experienced in removing work due to the presence of residual magnetism. The switch covers a terminal bracket in which there are mounted connections which may be instantly adjusted to provide for taking current for the chuck from a 110- or 220-volt circuit. These connections are accessible by merely removing four screws that hold the switch in place. The connections consist of two pairs of short brass levers carried on pivots; by swinging these levers into engagement with the proper contact points, the chuck is ready for connection with either of the electric circuits of the two commonly used voltages.

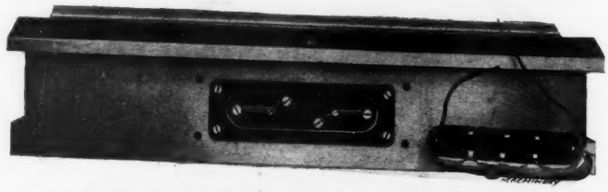


Fig. 3. Chuck with Switch Box removed to reach Terminal Connections, which may be adjusted to adapt Chuck for Use on 110- or 220-volt Circuits

In working out the design of these chucks great care has been taken in the selection of materials that experience has shown to be best suited for the respective parts of magnetic chucks. Swedish iron is used for the poles, because this material has exceptionally high magnetic permeability and may be instantly demagnetized and left free from residual magnetism. These poles are drop-forgings. The cores on which the electromagnet coils are mounted are set on non-magnetic washers, which provide for effectually insulating the cores from the chuck body. The coils are wound with single cotton-covered enameled magnet wire; they are wound on collapsible

forms on a universal winding machine. A fiber casing is placed inside each coil which serves the double purpose of insulating the coil from the core, and also protecting the insulation on the wire while the coil is being slipped over the steel core. Brass clips are also placed at the center of each coil to prevent its shape being distorted during the performance of manufacturing operations which come between the completion of winding the coil and the time that it is slipped onto the core. The coils are impregnated with "Sterling" extra insulating varnish, after which they are baked. The next step is to give the coils a dipped coat of varnish, after which they are baked a second time; each coil is then given a brush coat of varnish, and baked for the third and last time. All the coils in a chuck have the same number of ampere turns of wire, so that equal holding power is provided on all surfaces of the chuck.

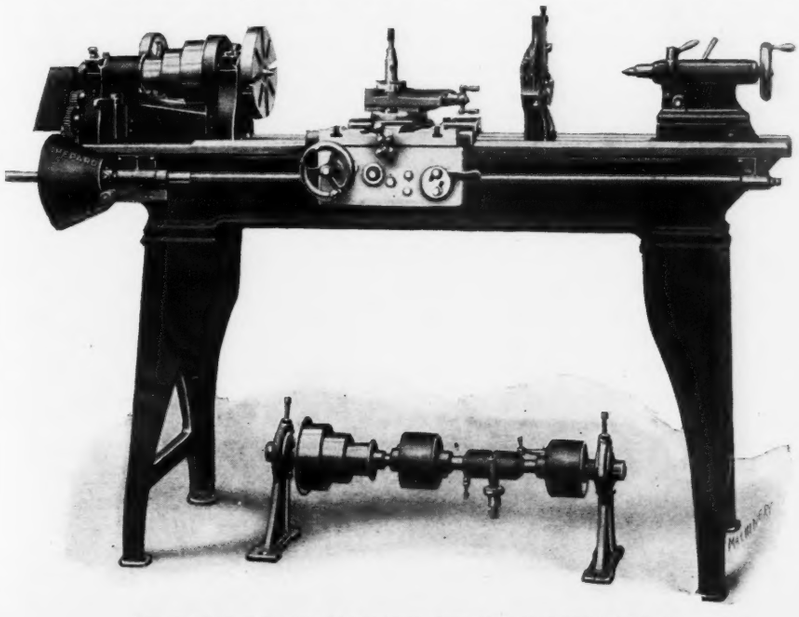
The rotary chucks are made in various standard and special sizes. These chucks are made in two types, one of which has the interlocking arms of opposite poles arranged on concentric circles, as shown in Fig. 1, the object being to bring the poles of opposite polarity so close together that very small pieces of work can be held. The other type of rotary chuck is equally serviceable for all classes of work which are not of extremely small sizes. The so-called "surface" chucks shown in Figs. 2 and 3 are also made in various standard and special sizes to accommodate a wide range of work. These chucks are made in two types, those for use on planers and milling machines having a T-slot at the front in which a work finger is held to provide for holding the work against the back-rest. This additional support is not required in the case of magnetic chucks used on surface grinders.

"Filsmith" Gap Lathe, which swings 22 Inches in Gap and 14 Inches Over Ways

"FILSMITH" GAP LATHE

There are many shops where it is occasionally necessary to turn a large pulley or plate, although the amount of work of this kind is not sufficient to justify investment in a lathe of the required swing for handling such operations. To meet the requirements of shops of this kind, a gap-bed lathe is usually selected because it can be used on regular production work, and when the exceptional job comes along, the additional swing provided by the gap bed is found very useful.

The Philip Smith Mfg. Co., Sidney, Ohio, is now building the "Filsmith" gap lathe shown in the accompanying illustration. A 20-inch pulley with a 4-inch face is shown in place on the lathe, and below is shown the section of bed which can be secured in the gap when only the normal swing of the machine is required. To enable the lathe to stand up under the exceptional conditions of service for which it is occasionally employed, in addition to giving satisfactory results on general lines of work, the machine is rigidly constructed. The swing over the ways is 14 inches, while a swing of 22 inches is obtained in the gap. It only takes a few minutes to remove the gap piece or replace it to adapt the machine for handling work that comes within the range of a 14-inch lathe. This machine is built with 5-, 6-, 8-, 10- and 12-foot beds, and it is also furnished with a quick-change gear-box if so desired.



Engine Lathe with Semi-quick-change Gear built by Shepard Lathe Co.

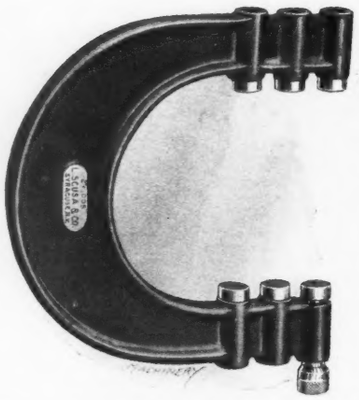
SHEPARD ENGINE LATHE

The 12-inch semi-quick-change engine lathe shown in the accompanying illustration is a recent product of the Shepard Lathe Co., 217 E. 8th St., Cincinnati, Ohio. Attention is called to the following features of design: A reversing clutch in the headstock makes it unnecessary to reverse belts or watch a dial when chasing threads, because this reversing clutch enables the lead-screw nut and change-gears to remain in constant engagement, the feed of the lathe being instantly reversed by operating the small lever which will be seen on the headstock. It will be obvious that this is the means of saving time when chasing threads in addition to simplifying the operation. Another feature is the design of the semi-quick-change feed mechanism which locates and locks all of the change-gears in a cone on the feed-rod. By shifting this cone of gears back and forth, the required gear is swung into mesh. All gears are always in place on the machine, so that no time is lost in finding the desired gears for a given combination. It will be apparent from the illustration that the carriage has a bearing of ample length on the ways and also that the bearing on the compound rest is of ample size to assure freedom from vibration.

The headstock is of the back-geared type and furnished with a hollow spindle made of 50-point carbon steel. This spindle runs in phosphor-bronze bearings and has a hole 1 inch in diameter extending all of the way through. The three-step cone pulley carries a 2-inch belt. The tailstock is of the offset type and provision is made for setting it over to provide for the performance of taper-turning operations. This machine is built in 10- and 12-inch sizes and both machines

may be furnished for drive from an overhead countershaft or by an individual motor. In addition to the cone-pulley driven machine, lathes of this type are built with a geared head. Extra attachments made for use with this machine include a milling attachment, taper-turning attachment, turret attachment, and draw-in collet chuck. A compound rest, steady-rest, faceplate, friction countershaft, gear guards, and the necessary wrenches for making all adjustments are furnished with the lathe as part of the regular equipment.

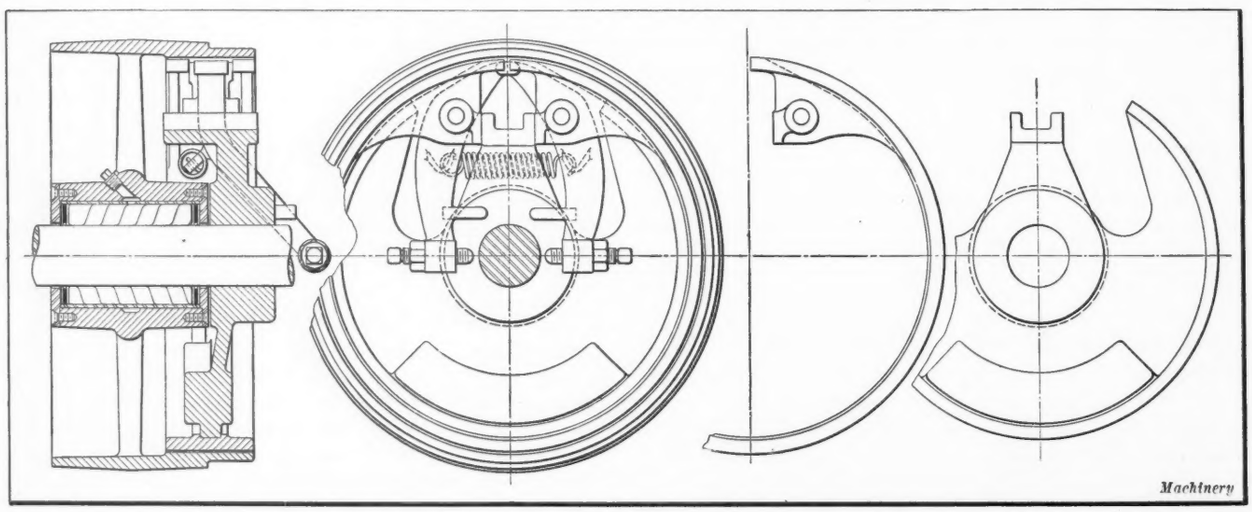
The principal dimensions of the 12-inch machine are as follows: actual swing over bed, 12¼ inches; diameter of hole through spindle, 1 inch; size of front and rear spindle bearing, 1 9/16 by 2 1/4 inches; cone pulley diameters, 6, 4½, and 3 inches; ratio of back-gears, 7 to 1; diameter of lead-screw, 15/16 inch; length of carriage bearings on bed, 14½ inches; size of lathe tools, ½ by 1 inch; speed of countershaft, 225 R. P. M.; range of spindle speeds, 25 to 425 R. P. M.; length of bed, 4 feet, 3 inches; 5 feet, 3 inches, or 6 feet, 3 inches; and capacity between centers for above lengths of bed, 25, 36, and 48 inches, respectively.



Scusa Combination Limit Snap Gage and Micrometer

limits may be provided to meet requirements of different shops. No change can take place except as the result of wear, and adjustment is easily effected by means of screws set in the end of the plugs. Similar adjustment is furnished for the micrometer anvil. After making the required adjustment, the screws are sealed.

The micrometer screw is essentially the same as that in the standard instrument, being ¼ inch in diameter and 40 pitch, with a head graduated to read to 0.001 inch from 0.0005 to 0.125 inch over size. The object of having a limit of 0.0005 is to serve as a check to prevent the operator making work too small. This screw is provided with positive stops in either direction. It will be seen that the frame is of double ribbed section, which affords stiffness without unduly increasing the weight and also provides a convenient and secure grip on the gage. The frame is finished with baked black enamel and the gage limit sizes are stamped on a polished pad where they are easily seen. The accompanying table shows the series of sizes in which the Scusa combination limit snap gages and micrometers are made.



Roller Bearing Friction Clutch built by Accurate Machine Co. and equipped with Hyatt Roller Bearings

SCUSA SNAP GAGE AND MICROMETER

L. Scusa & Co., Syracuse, N. Y., are now making a line of combination limit snap gages and micrometers of the type illustrated and described herewith. These tools are designed to meet the demand for gages which can be used for measuring those classes of work on which ordinary snap gages are employed and also provide means of rapidly determining just the amount of stock which it is necessary to remove in order to enable a piece of work to enter the limit gage without in any way interfering with the usual function of such a gage. An advantage of this combination is that gaging may be accomplished without offering any temptation for the inspector to force the gage onto the work, thus removing the danger of springing the gage open and reducing wear on the "go" surface to a minimum. Hardened tool-steel measuring plugs are forced into accurately reamed seats in the frame and are sealed by the inspector. These plugs are ground and lapped on their measuring faces and various

SIZES IN WHICH SCUSA COMBINATION SNAP GAGES AND MICROMETERS ARE MADE

Inch	Inch	Inch
⅜ to ½	3 to 3¼	6 to 6¼
½ to ⅝	3¼ to 3½	6¼ to 6½
⅝ to ¾	3½ to 3¾	6½ to 6¾
¾ to 1	3¾ to 4	6¾ to 7
1 to 1¼	4 to 4¼	7 to 8
1¼ to 1½	4¼ to 4½	8 to 9
1½ to 1¾	4½ to 4¾	9 to 10
1¾ to 2	4¾ to 5	10 to 11
2 to 2¼	5 to 5¼	11 to 12
2¼ to 2½	5¼ to 5½	12 to 13
2½ to 2¾	5½ to 5¾	13 to 14
2¾ to 3	5¾ to 6	.....

Machinery

ROLLER BEARING FRICTION CLUTCH FOR MACHINE TOOLS

The average machine shop has at times experienced considerable trouble with countershaft clutches, due to slipping of the friction surfaces and worn or hot bearings. This has resulted in the inefficient operation of the machine and involves time and expense in making the necessary repairs. A clutch built by the Accurate Machine Co., Cleveland, Ohio, is designed, under the patents of F. Demuth, to overcome these objections. The distinguishing features of this design are the large area of friction surface, the automatic self-tightening friction ring and the Hyatt roller bearing with which it is equipped. The illustration shows the general construction of the clutch, which consists principally of a pulley, friction ring and spider. The counterbalanced spider supports and drives the friction ring, and the driver fits in the space which is formed between the two lugs cast at each side of the split on the friction ring. This driver bears

against either of the lugs, and as the pressure increases a corresponding pressure will be increased between the friction ring and friction surface on the pulley, thereby making an automatic self-tightening clutch.

Slots in the spider on each side of the driver allow sufficient space for the operation of the clutch fingers. Both clutch fingers are supported on pins which are mounted in the lugs on the friction ring. As the thimble forces the fingers apart and the other ends of the fingers act against each other, the pins act as a fulcrum which expands the friction ring out against the friction surface of the pulley. It requires a slight pressure to force the thimble between the clutch fingers, and then the tightening of the clutch is automatic. The use of a roller bearing in the clutch pulley will eliminate wear and hot bearings, due to the self-lubricating and anti-friction qualities of the bearings. A large supply of lubricant is retained in the bearing housing, so that an additional supply of oil is required only at long periods of time. This provision of an oil reservoir carrying a supply of lubricant sufficient to last for several months greatly reduces danger of damage to the mechanism through failure of the attendant to provide oil.

T. P. WALLS MULTIPLE SAW AND BEVELING TABLE

The T. P. Walls Tool Co., Inc., 75 Walker St., New York City, is placing on the market a multiple saw and beveling table, consisting of eleven circular saws and ten bevel cutters placed one inch apart on an arbor 1⅛ inch in diameter and driven by a ½-horsepower motor. The saws are adequately guarded and the work is held in position by ten spring steel fingers operated by a handle behind the finger plate. This machine was originally built for the purpose of cutting player-piano action air-valves into one-inch units and beveling them on one edge. These air-valves are made in strips about eleven inches long, each strip containing ten valves. Heretofore it has been the practice to cut these valve units one at a time, and then to bevel the edge of each valve unit separately. By the use of the multiple saw and beveling table, what formerly consisted of twenty-one operations is done in a single operation. The saws on the multiple table may be adjusted any distance apart down to 1/32 inch, thus making the table adaptable for many purposes, such as making combs, box corners, strips for wood dowels, etc. These machines are furnished in such sizes as may be required for any specified multiple cutting or beveling.

Fig. 1. T. P. Walls Multiple Saw and Beveling Table

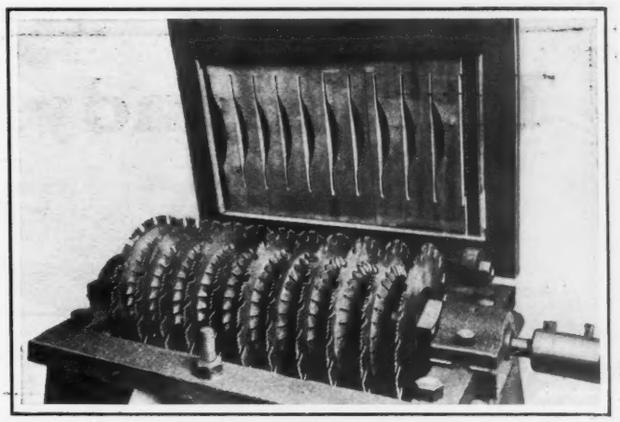


Fig. 2. Close View of Saws and Bevel Cutters

NEW MACHINERY AND TOOLS NOTES

Drilling Machine: Smith Engineering Works, 32nd and Locust Sts., Milwaukee, Wis. A 24-inch high-duty drilling machine on which ten speed changes are obtainable covering a range from 30 to 446 revolutions per minute. Six changes of feed are provided, covering a range from 0.007 to 0.071 inch per spindle revolution.

Demagnetizer: W. F. Davis Machine Tool Co., 549 W. Washington St., Chicago, Ill. A device made in different sizes and claimed to be able to completely demagnetize metal parts as fast as they can be passed through it. This device is particularly adapted for demagnetizing parts that have been machined on magnetic chucks.

Diamond Tool-holder: National Machine Co., 135 Sheldon St., Hartford, Conn. This firm is now making the "Hartford" diamond tool-holder for use in truing the wheels on surface grinders. Provision is made for holding the diamond tool at any angle, and the tool is firmly supported, which is claimed to add to the accuracy that can be obtained in wheel truing.

Plug and Ring Gages: Reliable Machine Works, 48 Lafayette St., Ridgewood, L. I., N. Y. A line of plug and ring gages equipped with revolving grips which are convenient to use. With this arrangement the gages may be used for testing the size of a piece being machined without requiring the machine to be stopped, as the revolving handle may be conveniently held while the gage is revolving with the work.

Grinding and Polishing Stand: St. Louis Machine Tool Co., St. Louis, Mo. A line of grinding and polishing stands which are provided with 0.40 carbon steel arbors that run in dustproof bearings lined with anti-friction metal and provided with automatic lubricators. The work-rests are of improved design and back-rests are furnished for receiving a wheel-guard or other fixture.

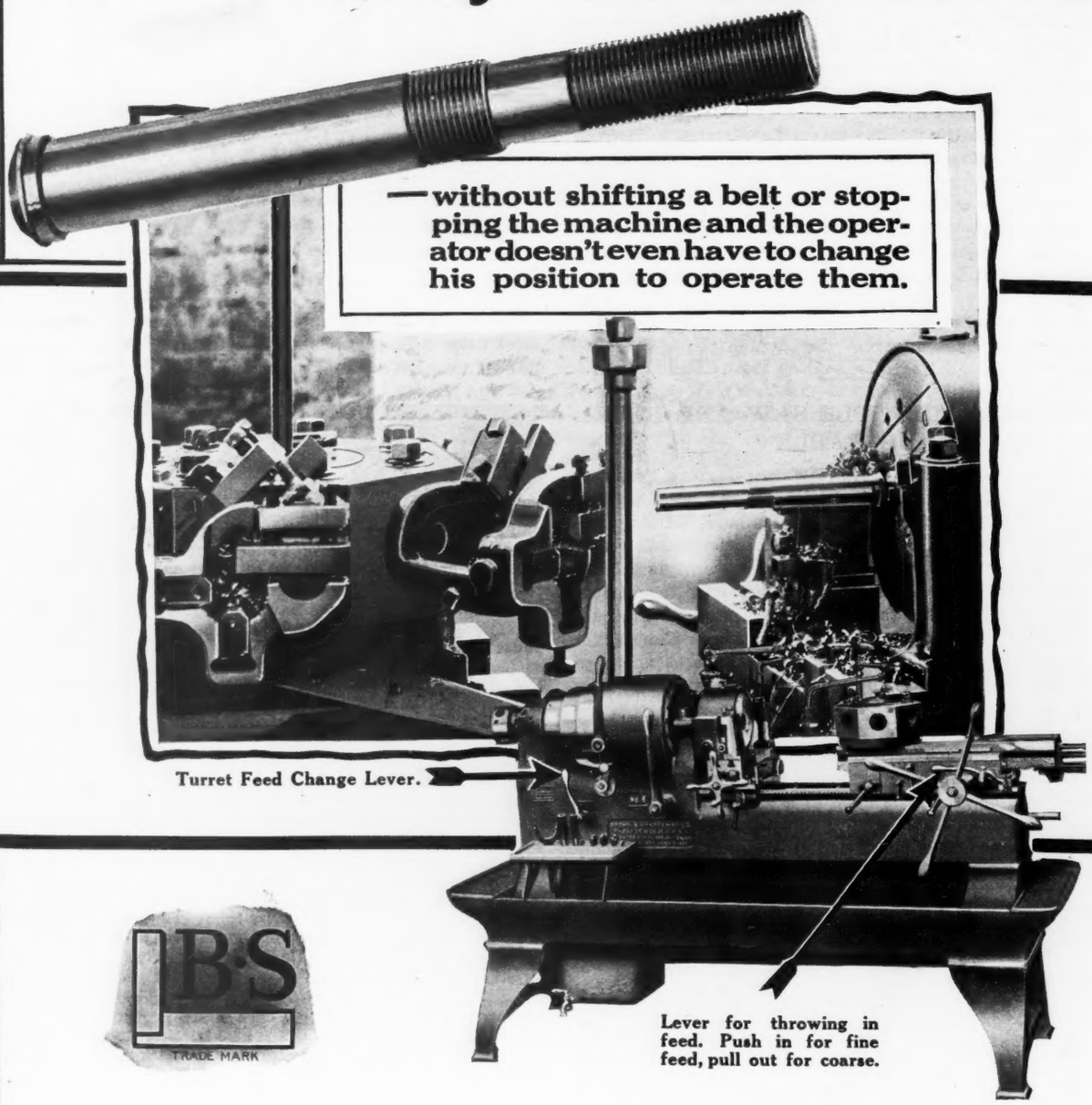
Tapping Machine: Rickert-Shafer Co., 612 W. 12th St., Erie, Pa. A vertical tapping machine for tapping holes from ¼ to ½ inch in steel, and from ¼ to ⅝ inch in cast iron. It is styled a ½-inch Model R tapping machine. Forward and reverse motions are obtained through a patented friction drive in which there is said to be practically no lost motion between the driving and reversing of the tap.

Pyrometer Tube: Charles Engelhard, 30 Church St., New York City. A line of pyrometer protecting tubes which are sold under the trade name of "Impervite." The claim is made for the properties of these tubes that they are practically identical with that of the Marquardt, including the coefficient of expansion, mechanical strength and porosity. The melting point of the tubes is claimed to be above 3500 degrees F.

Thread Gage: Coats Machine Tool Co., 30 Church St., New York City. A special thread gaging fixture which is made by the H. E. Harris Engineering Co., and is sold by the above concern. The stand of this fixture is of new design, but the gage is the standard type of Prestwich fluid gage. Graduations on a vertical scale are ⅛ inch apart and each represents a variation of 0.0001 inch in the work.

Spoticator: Reliance Tool Co., Meriden, Conn. A tool for use on milling machines for spotting holes and for performing lining operations on jig, die and similar work. This instrument will spot holes on the work as accurately as the table of the milling machine may be moved by its screws. The spotting is done by a prick-punch that is normally held out of engagement with the work by a spring.

Two Handy Levers Provide th



—without shifting a belt or stopping the machine and the operator doesn't even have to change his position to operate them.

Turret Feed Change Lever.

Lever for throwing in feed. Push in for fine feed, pull out for coarse.

B·S TRADE MARK

The simple movement of one or both of these levers is all that is required to get the most productive feed for each turret operation, eight feeds in geometrical progression being instantly available for each spindle speed.

Practically no more effort is required to use the correct feed for each operation than to use the same feed for the entire seven tools.

This "self-contained-turret-slide-feed" feature of Nos. 4 and 6 B & S Wire Feed Screw Machines is but one of their many points that make for handiness and consequently FAST PRODUCTION. It will pay you to investigate these efficient machines in detail.

Send for Catalog 21-G

Brown & Sharpe Mfg. Co., P

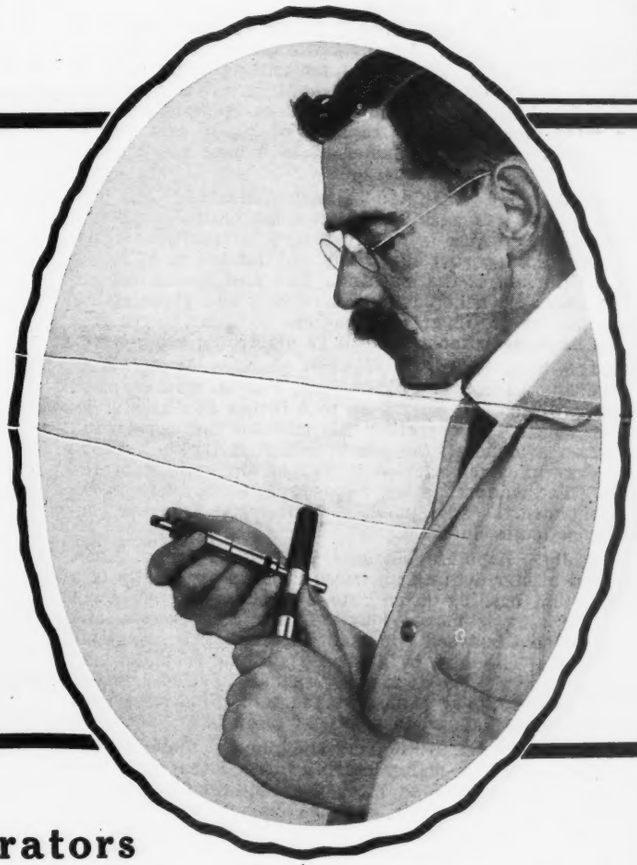
OFFICES: NEW YORK, N. Y., 20 Vesey St. PHILADELPHIA, PA., 1103-1105 Liberty Bldg. CHICAGO, ILL., 626-630 Washington Blvd. ROCHESTER, N. Y., 415 Chamber of Commerce Bldg. SYRACUSE, N. Y., Room 419 University Block. PITTSBURGH, PA., 2538 Henry W. Oliver Bldg. CANADIAN REPRESENTATIVE: MONTREAL, TORONTO, WINNIPEG, CALGARY, VANCOUVER, ST. JOHN, SASKATOON, The Canadian Fairbanks-Morse Co., Ltd.

the Correct Speed and Feed For Every Operation on This Piece

Brown & Sharpe

Nos. 4 and 6

Wire Feed Screw Machines



Screw Machine Operators

the same as all mechanical workers, demand an accurate, handy, adaptable way of keeping their work to predetermined limits. Accuracy must not be sacrificed for fast production. Both can be maintained by the use of "Brown & Sharpe Equipment." A small but important part of this equipment are the precision tools employed. Brown & Sharpe Tools have supplied, for three generations, the handy, adaptable, sure method of keeping the work of the machine tool operator, the machinist and the toolmaker up to the highest standards of accuracy.

Brown & Sharpe Machinists' Tools

Not only should shop superintendents and foremen specify B & S Tools for their tool cribs, but they should encourage their men to buy them for their kits. Better work and faster production naturally follow such a course.

Send for Catalog 27
listing the thousand varieties of these world-known and world-endorsed tools

Providence, Rhode Island, U.S.A.

REPRESENTATIVES: BALTIMORE, MD., Carey Machinery & Supply Co. CINCINNATI, O., INDIANAPOLIS, IND., The E. A. Kinsey Co. SAN FRANCISCO, CAL., Pacific Tool & Supply Co. CLEVELAND, O., DETROIT, MICH., Strong, Carlisle & Hammond Co. ST. LOUIS, MO., Colcord-Wright Machinery & Supply Co. SEATTLE, WASH., Perine Machinery Co. PORTLAND, ORE., Portland Machinery Co.

Electric Riveting Machine: New England Machinery Co., New Haven, Conn. A machine known as the "Kobert" electric riveting and forging machine. It is of the two-unit single-cycle power type, in which the rivets are heated and driven at a single operation. The two units employed are the copper heating electrodes and the steel forging set, both of which are mounted on a swinging frame so that either set can be brought over the work.

Power Hacksaw: Peerless Machine Co., 1611 Racine St., Racine, Wis. A high-speed power-driven hacksaw which is provided with six changes of speed, covering a range from 50 to 150 strokes per minute. These speed changes are obtained by gears. If desired, the machine can be equipped with individual motor drive, with the motor mounted above the machine to economize floor space. The capacity of the machine is for work up to 6 by 6 inches.

Gear-hobbing Machine: Goss Printing Press Co., 1535 S. Paulina St., Chicago, Ill. An automatic gear-hobbing machine which was originally constructed for cutting gears used in printing presses of this company's manufacture. The machine is now being built for the market. It is made in one size with a rated diametral pitch capacity of 2½ in cast iron or steel, a maximum pitch diameter of 36 inches, and a maximum face width of 12 inches.

Surface Grinding Machine: Abrasive Machine Tool Co., Providence, R. I. A machine in which the entire frame is a one-piece casting which is rigidly braced internally to resist distortion, and supported at three points located in a way to insure equilibrium of the machine. The unit system of construction has been adhered to in designing and planning for the manufacture of this grinder, and any unit can be removed from the machine without materially disturbing other parts.

Thread Milling Machine: Newton Machine Tool Works, Inc., 23rd and Vine Sts., Philadelphia, Pa. A machine used for milling worms and screws up to 6 inches in diameter by 16 feet in length. In operating this machine the work blank is placed on a mandrel, the end of which is inserted into a tapered draw-in chuck carried in the hollow spindle of the machine. The mandrel is not released until the work is entirely completed, as adjustment for successive leads is controlled by a tooth clutch.

Drilling Jig: Lapointe Machine Tool Co., Hudson, Mass. A universal master drilling jig which consists essentially of a movable guide bushing fitted into a bushing carried by a slide. This slide is moved longitudinally by a screw, and the work is held between two stationary and two adjustable gripping jaws. The table is fitted to a circular base and may be rotated through 360 degrees. Graduations are provided indicating movements of 0.5 degree, and both adjusting screws are provided with dials graduated to 0.0005 inch.

Turret Lathe: W. K. Millholland Machine Co., Indianapolis, Ind. A 2½- by 30-inch manufacturing turret lathe which has been especially designed to meet the requirements of factories where unskilled labor has been employed to take the place of skilled mechanics. As far as possible, unnecessary parts have been eliminated, and the operation of the machine has been simplified so that a minimum number of movements are made by the operator. All parts are of substantial design, and this coupled with simplicity of operation, makes the machine practically fool-proof.

Universal and Plain Milling Machines: Ford-Smith Machine Co., Ltd., Hamilton, Ont., Canada. One of these is a No. 3 universal milling machine, with a longitudinal feed of 30 inches, cross-feed of 10 inches, and vertical feed of 19 inches; twelve changes of feed are obtainable, ranging from 0.006 to 0.092 inch per revolution. The other machine is a No. 3 plain milling machine which has a maximum longitudinal feed of 34 inches, vertical feed of 20 inches, and cross-feed of 10 inches; twelve changes of feed are available, covering the same range as given for the universal machine.

Cutting-off Machine: George Gorton Machine Co., Racine, Wis. A No. 2-D cutting-off machine which is equipped with a head carrying ten cutters supported in blocks driven into pockets in the bore of the head. One edge of each block is tapered and fits into a corresponding taper in the pocket. The cutters and blocks are located centrally by means of a tongue and groove construction. An automatic adjustable power feed mechanism is provided, making it unnecessary for the operator to reverse clutches when he is ready to raise the cutter-head after finishing a cut. A handwheel is employed to raise or lower the cutter-head, and it automatically disengages the feed mechanism when raising the cutter-head.

Turbine Grinder: Henry Perkins Co., Bridgewater, Mass. An air-driven turbine grinder of the portable or so-called "hand" type, which is used for grinding intricate castings. Air is supplied to a single row of turbine blades through six nozzles, and after expansion it flows through open ports located at the side of the housing. The axial thrust developed through the use of only a single row of blades, is carried by a thrust bearing. The rotor is 6 inches in diameter and runs at a maximum speed of 12,000 revolutions per minute when operating with air at a pressure of sixty pounds per square inch. The normal operating speed is from 10,000 to 11,000 revolutions per minute, and the machine carries a grinding wheel 2 or 2½ inches in diameter.

Crankpin Forcing Press: Watson-Stillman Co., 192 Fulton St., New York City. A portable press used for forcing crankpins into locomotive and engine wheels and for miscellaneous shop and field work. The press is mounted on a four-wheeled truck so that it may be conveniently pulled around the shop. A power-driven pump is substituted for the hand-pump used on previous equipments of similar type built by this company. Aside from reducing the number of men required by one, it is stated that the increased speed of operation is 300 per cent through the use of a power-driven pump. Presses of this type are built in capacities ranging up to 300 tons, and each is equipped with a gage to indicate the pressure required to sink the pin into place.

Boring Mill: Pawling & Harnischfeger Co., Milwaukee, Wis. A horizontal drilling and boring machine that incorporates a number of unusual features in its design. Dynamic braking is used to control the forward and reverse motions of the spindle, this being especially useful in the performance of tapping operations. The spindle is supported by bronze bearings and a heavy sleeve that runs out to the end of the spindle's travel. The operating switch is mounted at the top of the column and the switch control handle is placed at the front of the carriage. Control of the motor field rheostat is by a lever located near the control switch lever. All other operating levers and handwheels are centralized so that all mechanism may be readily controlled from the operator's position near the carriage.

* * *

THE CRUCIBLE SITUATION[1]

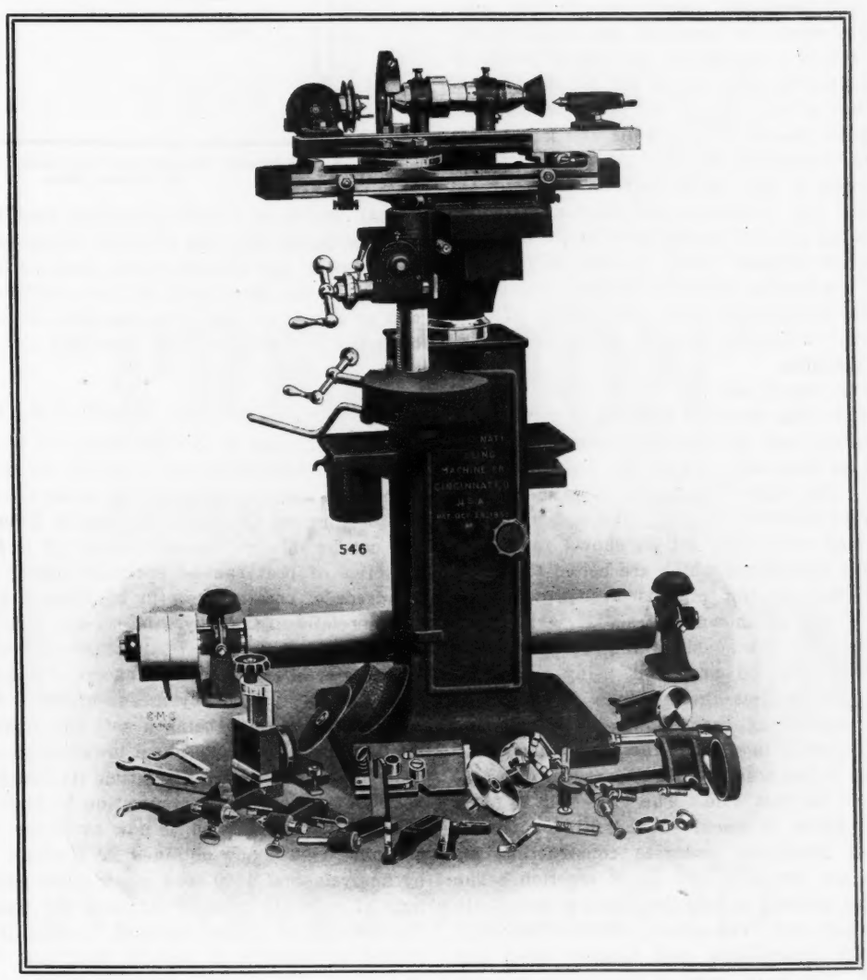
The important and essential ingredients of the plumbago crucible are the plumbago itself and the clay which serves to hold the crucible together in the process of manufacture and in use. Before the war, all the clay for crucible purposes was imported, and probably 95 per cent of the plumbago. The clay came almost exclusively from Germany. Shortly after the war opened, Germany prohibited the shipment of this clay, perhaps foreseeing the large demand of the Allies for ammunition and metals from this country, so that the manufacturer was launched on the sea of experiment at a time of rapidly increasing demand. The chemical and physical laboratories have been called upon in the search for a suitable substitute for the German clay, but the results of such investigations have for the most part been negative; that is, such investigations enabled only the elimination from real test such metals as did not measure up to such standards as have come to be recognized.

A great many clays have been examined, and perhaps a score have given indications of possible successful use. A clay giving favorable indications is mixed in varying proportions with the other ingredients of the crucible, among which may be other clays (for at the present time a blended clay seems to be the solution), and trial lots are made of each mixture. Owing to the long time required to make and burn crucibles, and adding to the time required for transportation and actual use, two months is the least period required to get results from such tests. If the result of such a trial is favorable, another lot is made up, this time of fifty or one hundred, and sent out to different users. If the results obtained by the different users are in practical agreement, the information is of real value; but when the reports are not in agreement, as is often the case, the test must, of course, be repeated.

In order to gain results as quickly as possible, many experiments have to be carried on simultaneously. Under such circumstances, a long time must elapse before information becomes available, but as the information accumulates there is steady progress toward the desired end. The results secured by the early attempts to use domestic clays were very unsatisfactory. In certain cases the average heats secured were four or five, as against twenty-five to thirty previous to the war. At the present time results are much better, from fifteen up to twenty and twenty-five heats being the range of average service. The above figures refer to an average size crucible, say No. 80, used in standard rolling mill practice.

[1]Abstract of an article by M. McNaughton, of the Joseph Dixon Crucible Co., published in the "Journal of the American Institute of Metals," September, 1917.

The Cincinnati Number 1 Cutter Grinder



FOR the medium and smaller sizes of spiral mills, end mills, side mills, angular cutters, etc.—in other words, for the cutters which are used most extensively—this No. 1 Grinder has been popular for many years.

Practically every shop of any consequence has at least one. Many large shops use dozens. They find it just as valuable for sharpening reamers as it is for sharpening cutters.

It is handy. Can be quickly set to any angle. The knee carrying the table swings through a complete circle, and in addition, the table may be set at an angle with the slide. Has graduated dials for all settings, and the lever feed can be operated from any position handiest for the work being done.

We are offering these machines for quick shipment

The Cincinnati Milling Machine Co.

CINCINNATI, OHIO

A REINFORCED CONCRETE BORING MILL

The general use of reinforced concrete for constructing bridges, viaducts, retaining walls, buildings and foundations has become accepted practice within the past decade. When properly mixed, placed and waterproofed, it is the most satisfactory and enduring building material known, but few are yet prepared to regard it as suitable for anything but fixed structures. It is true that reinforced concrete barges and even ships are in successful use, and the number promises to become rapidly greater as their seaworthy quality and comparatively low cost are demonstrated. Notwithstanding this remarkable proof of the value of concrete for purposes fulfilled almost exclusively by iron and steel, there are few machine designers and users who would concede that satisfactory machine tools could be designed and built of this material. But war brings revolutionary changes in social orders and industrial methods, and one of the changes we are likely to see is the use of concrete for the principal members of large special-purpose planers, boring mills and gun lathes.

Lucien I. Yeomans, consulting engineer, 72 W. Adams St., Chicago, who developed a shell lathe that is built without planing or boring the bed, headstock and tailstock, has designed a fifty-foot boring mill for emergency war work that is radical in conception throughout. Metal is used only for the driving parts, pivot, supporting strips or "skates," tool-slides, T-slots, table pan and reinforcing rods. The weight of steel and cast iron is thus reduced to a small percentage of the total weight of the machine.

The foundation and upper part of the bed are built of reinforced concrete following approved methods of mixing and placing in wooden forms, and the table-supporting strips are set with the aid of an engineer's transit by which accurate location is insured. The table foundation is a sheet steel pan filled with concrete reinforced radially and concentrically. The T-slots are formed with rails set as shown in Fig. 3. The ring gear is made in sections which are bolted to the reinforcing bars and two driving pinions are provided on opposite sides. Only one is shown in Fig. 1, which is a diagrammatic sketch only. The housings and cross-rail are a heavy monolithic structure, no provision being made for raising or lowering the rail, as the machine is for single purpose only. The reinforcing bars shown in the housing and coiled in the cross-rail in dotted lines are wrapped in the opposite direction in the other housing in order to oppose the thrust on the tool on that side. The cross-rail is faced with a cast-iron rail which is machined and fitted as usual.

The advantages of reinforced concrete construction for large machine tools are low cost and quick erection. The principal members can be built in less time than is ordinarily required to make the patterns. The pattern work on the metal parts is comparatively insignificant and foundry costs and delays are minimized. The heavy work is done on the ground, and the difficulties of railway transportation are largely eliminated, which is a most important consideration at present. It is estimated that this fifty-foot boring mill could be erected complete in any locality where building materials and ordinary machine shop facilities are available in three months and at a cost of less than one-fifth of that of the common design of mill having equal capacity.

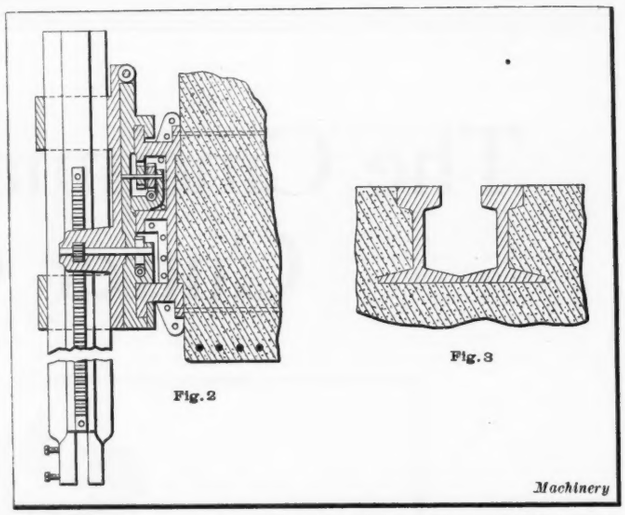


Fig. 2. Section through Cross-rail and Tool-holder. Fig. 3. T-slots formed by Railroad Rails

* * *

COKE FROM PEAT

The Peat, Coal & Oil Syndicate of Doncaster, Yorkshire, England, is developing a new method for treating a special dry black peat and converting it into a hard foundry coke, the by-products being tar and tarry liquids from which automobile oils can be obtained by distillation. It is not claimed that all varieties of peat can be profitably used, but it is said that hundreds of acres containing millions of tons of peat can be commercially utilized by this process. The black layer at the bottom of the bog is most suitable for the manufacture of coke. This material is freed of its excess of water and subjected to a carbonizing process by means of which by-products are recovered, the residue being a soft and friable coke. Notwithstanding that peat coke has a lower sulphur content than any other combustible, up to this time its insufficient hardness has been an obstacle to its application in blast-furnace operation. This fault, it is claimed, is now overcome, and a hard, strong and pure coke is now obtained. A German chemist has proved by analysis that 1000 tons of air-dried peat will produce 400 tons of coke, 40 tons of tar, and 400 tons of tarry liquids. The tar can be further distilled to yield 18 tons of crude oil, 2 tons of creosote, 2 tons of pitch and 8 tons of paraffin. The tarry liquids will yield 4 tons of sulphate of ammonium, 6 tons of acetate of lime and 2 tons of methyl alcohol.

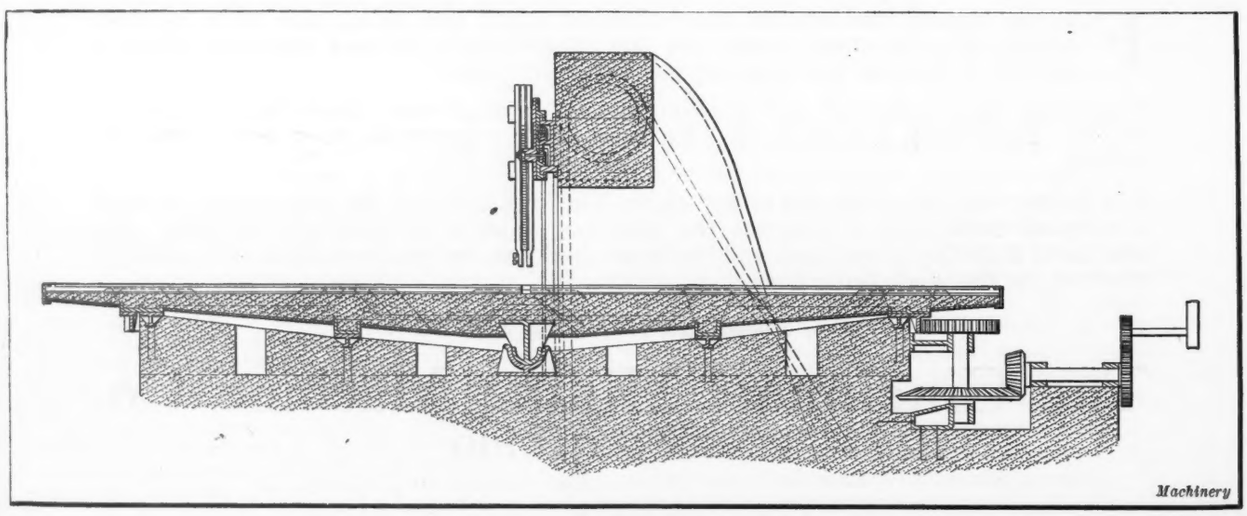


Fig. 1. Diagrammatic Sketch of Boring Mill

The LUCAS

(OF CLEVELAND)

"PRECISION"

BORING, DRILLING AND

MILLING MACHINE

ALWAYS GOOD

and as time goes on

ALWAYS BETTER

LUCAS MACHINE TOOL CO., NOW AND ALWAYS OF CLEVELAND, O., U.S.A.

DRAFTSMEN BADLY NEEDED FOR ORDNANCE DEPARTMENT

BY DYER SMITH [1]

The Ordnance Department of the United States Army is in great need of a considerable number of mechanical draftsmen. Some, and it is to be hoped many, of the readers of MACHINERY may be able to do a real patriotic service in this connection. There is so much opportunity for profitable employment everywhere these days that the supply of draftsmen for the Ordnance Department has been far behind the demand. So far there has been no conscription of any sort which would include them. Therefore, the recruiting for this service must be accelerated by volunteer work. The National Civil Service Reform League, 79 Wall St., New York City, is aiding the Ordnance Department in this. The lack of designers, detail men and tracers is causing important contracts for shells, guns and other equipment to be held up. Anyone who volunteers for this work aids in winning the war; five hundred more draftsmen in Washington now may considerably lessen the number of Americans who will never come home from France.

There are two grades of draftsmen called for: Grade 1, starting at $800 to $1400 a year, and Grade 2, starting at $1400 to $1800 a year. Applicants will not be required to report for examination at any place, but will be rated on general education, technical training and experience, and practical tests on work submitted. The requirements for the positions are listed in a number of alternative groups, including different amounts of drafting-room experience, graduation from or attendance at mechanical engineering courses, and combinations of both.

All interested are asked to write or call on the secretary of the National Civil Service Reform League, 79 Wall St., New York City, for further information and application forms. Anyone may help by applying himself, or by encouraging men employed by him to apply, or by telling his friends about the matter. The writer knows of no official ruling on the question of exemption under the draft for these men, but it seems evident that they will be "necessary employes of the government," who will be in a deferred class under the draft. Anyone who takes one of these jobs may feel that he is doing his patriotic "bit" in the way he knows best how to do. Many men who are unable to fight have wanted to help the government and have not known what to do. Here is an opportunity for effective service. Appointments will be made promptly on the basis of the training and skill of the applicant.

* * *

A GREAT ENGINEERING WORK COMPLETED

A meeting was held Wednesday evening, November 14, at the United Engineering Societies' Building, New York City, under the auspices of the United Engineering Society, to celebrate the completion of the Catskill water supply for the city of New York. At this meeting were present members of the four national engineering societies—the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. George H. Pegram, president of the American Society of Civil Engineers, presided, and an address was made by the mayor of New York City, John Purroy Mitchell, who gave credit to the engineers who had carried this remarkable engineering work, claimed to be the most difficult engineering feat ever completed, to a successful end. A. D. Flinn, deputy chief engineer of the New York Board of Water Supply, then gave a complete description of the work illustrated with lantern slides.

The water is carried by aqueducts and tunnels 120 miles from the Catskill mountains to New York. One of the most difficult engineering problems in connection with the work was the crossing of the Hudson River which was done by a tunnel 1200 feet below the surface of the river. It is of remarkable interest to note that this work was completed over a year before the estimated time of completion, or in less than nine years instead of in ten years as was expected, and also that the cost was below that estimated, the total cost having been $140,000,000 or $7,000,000 less than the original estimates. Great credit is certainly due those engineers whose ability, integrity and sense of public duty made it possible to complete this tremendous engineering work in so short a time and with such economy.

[1] Address: 32 Liberty St., New York City

* * *

RESIGNATION OF FRANK A. SCOTT

The resignation of Frank A. Scott from the chairmanship of the War Industries Board, in which position his unremitting devotion to duty seriously impaired his health, is only one instance of the strain to which such men are subjected. Executives who leave the management of well-organized and smoothly running business concerns to take government positions encounter difficulties in pushing the work forward to their satisfaction on account of the lack of organization and of efficient help. These troubles are inseparable from war conditions, and in most departments are being gradually remedied. The magnitude of the task we have assumed is visible to those behind the scenes, but on the great mass of our people it is only dawning.

* * *

With the help of able and efficient men in the machine tool and other industries, constant progress is being made in the organization of important work connected with the War Industries Board. G. E. Merryweather, of the Motch & Merryweather Machinery Co., Cleveland, whose office is now in the War Industries Building, has collected a large amount of statistical material in regard to the capacity and product of machine tool builders in this country and the condition of their orders, output and deliveries up to date, so that a glance at the card for each shop will show almost exactly what machines the government can count on from that shop and when they can be delivered.

* * *

It is mentioned in a French contemporary that the machine works of Fonderie des Gobelins, in Paris, have recently substituted stellite for high-speed steel for use in turning shells. By the use of stellite, a daily production of 120 six-inch shells was increased to 200. With high-speed steel, twenty minutes was consumed in taking a roughing cut at a speed of 60 feet; for finishing, the same speed was used. With stellite, the roughing speed was increased to 85 feet, and the finishing speed to 125 feet per minute. For completely finishing 1000 six-inch shells, the cost of stellite was found to be six cents per shell.

* * *

STATEMENT OF THE OWNERSHIP, MANAGEMENT, ETC. REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

of MACHINERY, published monthly on the 1st at New York, N. Y., for October 1, 1917.

State of New York } ss.
County of New York }

Before me, a Notary Public in and for the state and county aforesaid, personally appeared Matthew J. O'Neill, who, having been duly sworn according to law, deposes and says that he is the General Manager of MACHINERY and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, The Industrial Press	140-148 Lafayette St., New York
Editor, Fred E. Rogers	" " " " "
Managing Editor, None	
Business Managers { Alexander Luchars, President	" " " " "
Business Managers { Matthew J. O'Neill, Gen'l Manager	" " " " "

2. That the owners of 1 per cent or more of the total amount of stock are:

The Industrial Press	140-148 Lafayette St., New York
Alexander Luchars	" " " " "
Matthew J. O'Neill	" " " " "
Fred E. Rogers	" " " " "
Louis Pelletier	" " " " "
Erik Oberg	" " " " "

3. That there are no bondholders, mortgagees or other security holders.

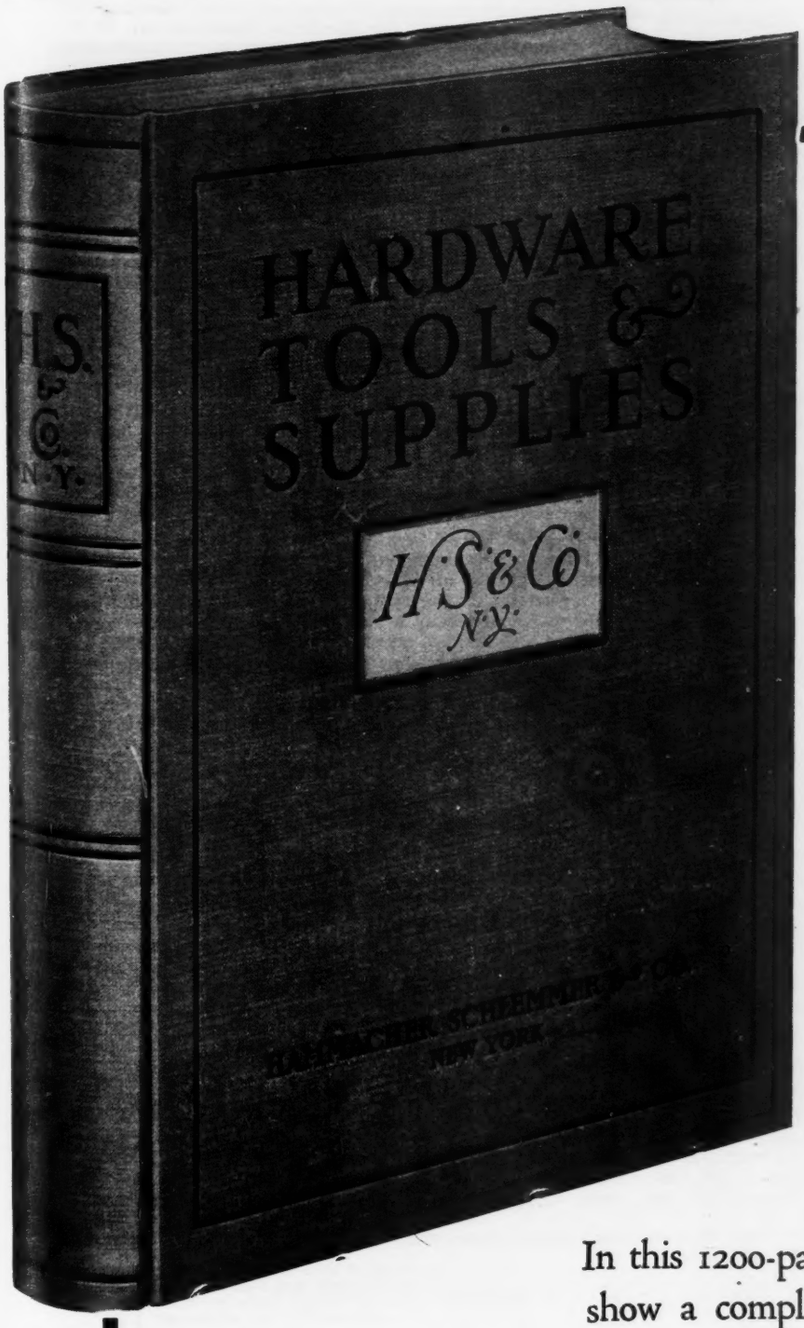
4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

MATTHEW J. O'NEILL, General Manager.

Sworn to and subscribed before me this 1st day of October, 1917.

THOMAS R. WILLIAMS,

(SEAL) Notary Public, New York County, No. 254.
(My commission expires March 30, 1918.)



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PERSONALS

Fred J. Miller, who for the past nine years has been general manager of the factories of the Remington Typewriter Co., has resigned.

Clarence M. Woolley, president of the American Radiator Co., New York City, has been appointed a member of the War Trade Board.

C. F. Heckman, formerly superintendent of the Russell Motor Car Co., Ltd., Toronto, Canada, is now superintendent of the Russell Motor Car Co., of Buffalo, N. Y.

J. E. MacArthur, formerly factory manager of the Russell Motor Car Co., Ltd., Toronto, Canada, has been made factory manager of the Russell Motor Car Co., Buffalo, N. Y.

L. R. Brink, superintendent of Barnhart Bros. & Spindler, Chicago, Ill., has resigned to become general manager of the Fort Dearborn Mfg. Co., Sterling, Ill., manufacturer of special machinery, gears and metal stampings.

W. C. Webster, who has been secretary and general manager and director of the Nichols Copper Co., 25 Broad St., New York City, for several years, has resigned. Mr. Webster expects to take a rest before assuming further duties.

C. R. Burt, for the past four years assistant general manager of the Russell Motor Car Co., Ltd., Toronto, Canada, has been appointed general manager and a director of the Russell Motor Car Co., of Buffalo, located at 93 Dewey Ave.

W. F. Trenary, Jr., now represents the Harrison Safety Boiler Works, Philadelphia, Pa., manufacturers of the Cochrane heaters and other steam plant appliances, succeeding W. R. Jennison. Mr. Trenary's headquarters will be 419 Brown-Marks Bldg., Birmingham, Ala.

R. J. Morgan has resigned his position with the Midvale Steel & Ordnance Co., and has been appointed supervisor of sales of the American Steel Export Co., Woolworth Bldg., New York City. Prior to his connection with the Midvale Steel & Ordnance Co., Mr. Morgan was with the Carnegie Steel Co. for thirteen years.

Walter C. Voss, formerly in charge of the Detroit office of the rim and tube division of the Standard Parts Co., has been transferred to Washington, D. C., to look after the business of the Standard Parts Co., at that important center. Mr. Voss is being replaced by Art A. Loeffler, formerly of the Jackson-Church-Wilcox Co., of Saginaw, Mich.

J. F. Sells, of the engineering staff of the National X-Ray Reflector Co., Chicago, Ill., has been appointed consulting illuminating engineer for the new business departments of the Henry L. Doherty Co., Central Stations. Mr. Sells is at present located at Mansfield, Ohio, where the Henry L. Doherty Co. operates the Mansfield Electric Light & Power Co.

Roy B. Woolley, formerly sales and advertising manager of the Standard Electric Stove Co., Toledo, Ohio, has returned to America, having served his enlistment in the American Ambulance Field Service at the Verdun front in France. He is now with the Society for Electrical Development, 29 W. 39th St., New York City, as an executive in the advertising department.

J. L. Replogle, vice-president of the American Vanadium Co., has been appointed Director of Steel Supply by the Council of National Defense. He will receive weekly reports from the iron and steel producers, which, in cases of retarded output, will state the reasons therefor. Every effort will be made to remove obstacles that prevent the maximum output of war necessities.

Samuel McRoberts has retired from the board of directors of the Allied Machinery Co., as government work takes all his time, and has been succeeded as chairman by R. P. Tinsley, vice-president of the American International Corporation. R. B. Sheridan has also retired as president of the Allied Machinery Co., but will continue as a member of the executive committee. J. W. Hook succeeds Mr. Sheridan as president.

Arthur C. Rogers, formerly connected with the advertising agency conducted under his name at Cleveland, Ohio, has been appointed a Major in the Ordnance Section of the Officers' Reserve Corps of the United States Army, and will shortly receive orders to active duty. The agency conducted under Mr. Rogers' name has been incorporated under the laws of Ohio as the Rogers-Brett-Baker Co., of which Mr. Rogers will still remain president.

Louis A. Freedman has been elected secretary of the Aeronautical Society of America, 29 W. 39th St., New York City. Mr. Freedman in the past has been engaged in some important aerodynamical research studies, is a member of several of the society's committees, a graduate of the Massachusetts Institute of Technology, and has followed the profession of mechanical engineering for a number of years. His achievements in inventing, designing and building automatic machinery for the production of dry batteries are especially noteworthy.

OBITUARIES

William R. Griswold, mechanical engineer with the Standard Tool Co., Cleveland, Ohio, died October 6, aged forty-nine years. Mr. Griswold had been with the Standard Tool Co. fifteen years.

Albert P. Bowe, formerly advertising manager of the Hydraulic Press Mfg. Co., Mount Gilead, Ohio, was accidentally shot and killed October 27 on the rifle range at Camp Perry. Mr. Bowe was called to the colors in September and had the rank of sergeant. He was not only capable and conscientious in his publicity work, but was representative of the standards that make for good citizenship.

William Thompson Iler, Jr., assistant works manager of the Slocum, Avram & Slocum Laboratories, Inc., New York City, died on October 18 of a complication of typhoid fevor and pneumonia, aged twenty-five years. Mr. Iler was a graduate in mechanical engineering of the New York University and a junior member of the American Society of Mechanical Engineers. He contributed a number of articles to MACHINERY.

COMING EVENTS

December 4-7—Annual meeting of the American Society of Mechanical Engineers in New York City; Engineering Societies Bldg., 29 W. 39th St., headquarters. Calvin W. Rice, secretary.

December 27—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

SOCIETIES, SCHOOLS AND COLLEGES

Michigan College of Mines, Houghton, Mich. Year book for 1916-1917, containing announcement of courses for 1917-1918.

American Society of Mechanical Engineers, 29 W. 39th St., New York City. Condensed catalogues of mechanical equipment for 1917, with mechanical equipment directory, containing 409 pages of catalogue data and a directory of 163 pages. Engineering data from recent publications of the society are included, covering 42 pages. The catalogue is divided into sections as follows: Part I, power plant equipment; Part II, power transmission machinery, elevating and conveying machinery, hoisting and transporting machinery; Part III, metals, alloys and other materials; Part IV, metal-working machinery, machine tools and accessories, shop equipment; Part V, compressors, fans, blowers, pumping and hydraulic machinery, drying and crushing machinery, and engineering miscellany; Part VI, testing, measuring and recording apparatus. There are 3200 firms listed in the directory, and catalogue data of 332 manufacturers are given.

NEW BOOKS AND PAMPHLETS

Year Book of the Bureau of Mines, 1916. By Van H. Manning. 174 pages, 6 by 9 inches. Published by the Government Printing Office, Washington, D. C. Price, 30 cents.

Effects of Storage upon the Properties of Coal. By S. W. Parr. 39 pages, 6 by 9 inches; illustrated. Published by the University of Illinois, Urbana, Ill., as Bulletin No. 97 of the Engineering Experiment Station. Price, 20 cents.

German Foreign-trade Organization. By Chauncey Depew Snow. 182 pages, 6 by 9 inches. Published by the Bureau of Foreign and Domestic Commerce of the Department of Commerce, Washington, D. C., as Miscellaneous Series No. 57. Price, 20 cents.

Comparative Basic Costs of Typesetting, by Hand, Linotype and Monotype. 54 pages, 5½ by 8 inches. Published by the Graduate School of Business Administration, Harvard University, Cambridge, Mass., as Student Reports on Business Problems No. 1. Price, 50 cents.

Glossary of Aviation Terms. By Victor W. Page and Paul Montariol. 94 pages, 5 by 7½ inches. Published by Norman W. Henley Publishing Co., 2 W. 45th St., New York City. Price, $1.

The book contains lists of the aeronautical terms in English with the French equivalents, and in French with the corresponding English words. It is arranged in four parts: Flying Field Terms; The Airplane and Its Parts; Engine Parts; and Tools and Shop Terms.

Some Unusual Features in the Microstructure of Wrought Iron. By Henry S. Rawdon. 25 pages, 7 by 10 inches. Published by the Government Printing Office, Washington, D. C. Price, 5 cents.

This is Technologic Paper No. 97, issued by the Bureau of Standards. It contains a number of photomicrographs and diagrams of wrought-iron structures, which will prove of interest to any student of metallography and metallurgy.

Experimental General Science. By Willard Nelson Clute. 303 pages, 4¾ by 7¼ inches; 96 illustrations. Published by P. Blakiston's Son & Co., Philadelphia, Pa. Price, $1.25.

This is a general text-book on a number of different scientific subjects written in popular form and intended particularly for school use. It is divided into fifty-two chapters, giving a brief outline of astronomy, chemistry, physics, including the science of heat, light, sound, electricity, and many other subjects.

Mechanical Processes. By G. W. Danforth. 423 pages, 6 by 9 inches; 270 illustrations. Published by the United States Naval Institute, Annapolis, Md.

This book is intended as an elementary course for engineering schools on the processes employed in shaping materials of construction for various mechanical uses, and shows briefly the steps of the manufacture of metal from the ore to the finished product. It contains thirteen chapters dealing with engineering materials; metal-producing processes; fuels; iron and steel; mechanical treatment of metals and heat-treatment of metals; remanufacture of metals; machinery building and repairing plants; drawings for shop use; the pattern shop; the foundry; the blacksmith shop; the machine shop; the boiler shop; and special processes.

Thomas' Register of American Manufacturers. 3900 pages, 9½ by 12 inches. Published by the Thomas Publishing Co., 129 Lafayette St., New York City. Price, $15.

This is the ninth edition of the Thomas' Register, published October, 1917. The work is divided into five sections. The first contains a finding list and index. The second contains a complete list of all manufacturers in the United States classified according to business or product. The third section gives the manufacturers in the United

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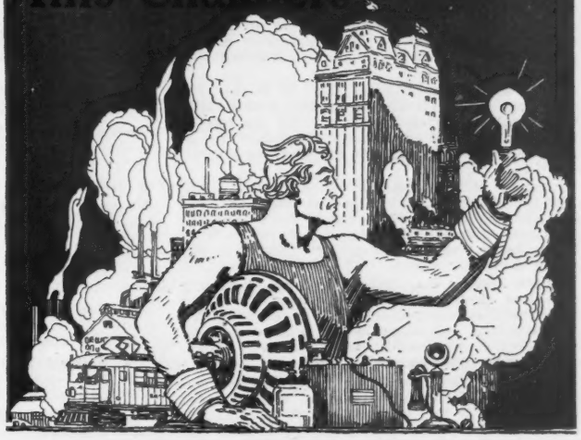

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States arranged alphabetically by name, giving the home offices, branches, and in many cases names of officers, sales managers and purchasing agents. The fourth section gives leading trade names, brands, etc. An appendix or fifth section is included, giving banks, boards of trades or other commercial organizations, leading trade journals, leading manufacturers' representatives, etc. In order to simplify the use of the work, the different sections are printed on paper of different colors, Section 1 being printed on yellow, Section 2 on white, Section 3 on blue, Section 4 on pink, and Section 5 on white paper. This work is claimed to be the largest publication of its kind ever issued. The revisions, new matter and improvements in the new edition have required 400 additional pages. A valuable feature of the work is that successors to firms are given; in cases where there have been business reorganizations, both the new and old firm names are listed in the alphabetical list of manufacturers. The work should be of special value not only to purchasing agents and men directly interested in the purchasing of machinery and supplies, but also to foremen, superintendents and others who have to do, in an indirect way, with the buying or specifying of machinery or supplies.

NEW CATALOGUES AND CIRCULARS

Frank P. Bickow, 33-35 S. DesPlaines St., Chicago, Ill. Circular of 10-inch index universal centers.

Metalwood Mfg. Co., Detroit, Mich. Folder B-40, descriptive of Metalwood single-lever, quick-operating hydraulic valves.

Morris Machine Tool Co., Cincinnati, Ohio. Circular descriptive of Morris lubricating attachment, universal tilting table and constant-speed motor drive.

Ingersoll-Rand Co., 11 Broadway, New York City. Form 3118, descriptive of compressors and vacuum pumps for the extraction of gasoline from natural gas.

Scientific Materials Co., 711 Forbes St., Pittsburg, Pa. Catalogue of improved American model of Brinell hardness testing machine with special depth-measuring gage.

Lovejoy Tool Co., Inc., Springfield, Vt. Catalogue of Lovejoy turning, facing and planing tools, of the positive-lock, inserted-cutter type, giving dimensions and prices.

Ingersoll-Rand Co., 11 Broadway, New York City. Form 859, advertising a convenient pocket oil-flask, weighing 3½ ounces and having a capacity for one-third pint of lubricant.

Draper & Hall Co., Middletown, Conn. Circular illustrating and describing the D. & H. universal grinder, which is adapted for external, internal, surface and cutter grinding.

National Machinery Co., Tiffin, Ohio. National Forging Machine Talk 29, descriptive of the dies for forging the nose piece for a 4.5-inch shell on National heavy-pattern forging machines.

Hall Gas Engine Co., Inc., Bridesburg, Philadelphia, Pa. Booklet descriptive of the Hall thread milling fixture for cutting external or internal threads of any form or pitch, straight or taper.

Worthington Pump & Machinery Corporation, 115 Broadway, New York City. Bulletin D-1301 treating of steam and electric automatic pumps and receivers, of the single, duplex and triplex types.

Oliver Machinery Co., Grand Rapids, Mich. Circular descriptive of the Oliver No. 74 universal vertical and horizontal wood-boring machine, belt- or motor-driven. The machine is equipped with ball bearings throughout.

American Petroleum Products Co., Williamson Bldg., Cleveland, Ohio. Pamphlet entitled, "Use of Oil as a Fuel," comprising a reprint of an article that appeared in MACHINERY treating of economy of fuel, storage and feeding systems, and types of burners.

Charles H. Besly & Co., 120-B N. Clinton St., Chicago, Ill. Catalogue containing illustrations of the Besly flat surface grinder in use on various classes of work, showing how production can be speeded up and manufacturing costs reduced with this machine.

U. S. Gutta Percha Paint Co., 19 Dudley St., Providence, R. I. Circular advertising Rice's "Mill-White" paint "Barreled Sunlight," for the interior of plants, which, it is claimed, will materially increase the amount of daylight and decrease the cost of artificial lighting.

Cleveland Milling Machine Co., Cleveland, Ohio. Stock list of cutters, giving the dimensions of Cleveland standard cutters which are in stock and from which immediate shipment can be made. This booklet is published on the 15th of each month and will be sent free upon request.

Chelten Electric Co., Philadelphia, Pa. Catalogue of Chelten electrical specialties, giving list prices of switches, plates, receptacles, attachment plugs, cord-connectors, indicating heater receptacles, indicating switch receptacles, fuses, ground clamps, switch boxes, cast-iron conduit boxes, etc.

Standard Pressed Steel Co., Philadelphia, Pa. Catalogue of the complete line of milled screws manufactured by this company, which includes hollow safety set-screws, cup- and oval-point set-screws, hexagon- and square-head cap-screws, fillister- and round-head cap-screws, flat-head and button-head cap-screws.

Esterline Co., Indianapolis, Ind., is issuing a publication entitled "The Esterline Graphic," which treats of the uses of the Esterline graphic meter, an instrument for making a continuous survey of the operation of electrical equipment. By means of this instrument the causes of trouble are detected, and shut-downs avoided.

National Machine Co., Hartford, Conn. Circular descriptive of the Hartford improved automatic surface grinder, with a capacity for grinding work 8 inches wide, 30 inches long and 12 inches high. The circular gives specifications for the grinder, details of installation and operation, and a detailed description of the various parts.

American Pulley Co., 4208-60 Wissahickon Ave., Philadelphia, Pa. Booklet entitled "Getting Maximum Pulley Efficiency," describing the mechanical construction of American steel split pulleys, giving the results of tests for belt slip made by engineers, and pointing out the advantages that can be expected through the use of American steel split pulleys.

S K F Ball Bearing Co., Hartford, Conn. Catalogue entitled "Wood-working Precision at High Speed," containing information on the application of S K F ball bearings in wood-working machinery, including band saws, circular saws, planers, surfacers and jointers, shapers, dowelers, lathes, veneer machinery, borers and wood milling machines and special machinery.

Borden Co., Warren, Ohio. 1918 catalogue of "Beaver" die-stocks and square-end pipe cutters, illustrating the complete line of cutting and threading tools made by the company. Several new "Beaver" tools are shown for the first time, one of these being the No. 3 "Beaver Junior" ratchet die-stock, which is built on the unit plan to thread pipe from ⅛ to 1 inch diameter, inclusive.

Simonds Mfg. Co., Fitchburg, Mass. Catalogue entitled "Saws Sammy Showme Saw," containing reproductions of twelve advertisements that were published in MACHINERY. This series of advertisements shows the quest of Sammy Showme for the best metal selling practice throughout the country. The work done by Simonds semi-high-speed steel saws, hacksaws, high-speed steel inserted-tooth saws, screw-slotting saws and slitting saws, as seen by Sammy Showme, is strikingly illustrated.

Fellows Gear Shaper Co., Springfield, Vt. Handbook for operators of Fellows gear shapers, comprising a treatise on commercial gear cutting of spur, helical and internal gears. The principle of tooth generation by the gear shaper is clearly described, as is also the method of generating the cutters. The three kinds of cutters—form, hob and gear shaper cutter—are compared. A complete description of the generated cutter at work is given, and its various advantages are pointed out. The book concludes with descriptions of the No. 6 Fellows gear shaper, No. 65 helical gear shaper, and other sizes of gear shapers. Examples of work cut on the gear shaper are shown, including shoulder gears, cluster gears, helical gears, internal helical gears, herringbone gears, silent chain sprockets, ratchets, cams, irregular shaped work, keys and splined shafts. The descriptive matter is made very clear by the use of numerous halftone and line illustrations.

Merchants National Bank, 28 State St., Boston, Mass., has issued a pamphlet entitled "Women's Work in War Time," for the purpose of assisting manufacturers in this country to meet the shortage of labor. Much of the information has been obtained direct from the British government and other authoritative sources. The operations of the leading industries in England wherein women have replaced men are outlined, and modifications have been suggested to meet industrial conditions in this country. The industries covered are wool industry, cotton industry, printing, bleaching and dyeing, hosiery and knitting, clothing manufacture, leather tanning and currying, boot and shoe manufacture, glove industry, soap and candle trades, paper making, glass bottle trade, woodworking trades, pottery and brick trade, china and earthenware trade, silver and electroplate trades, chemical industries, color, paint and varnish trade, and sugar refineries. The book also includes a compilation of the state labor laws relating to female and child labor, and a chapter on welfare work in war time.

TRADE NOTES

Keller Pneumatic Tool Co. has moved from Fond du Lac, Wis., to Grand Haven, Mich.

Precision Die Casting Co., Inc., Syracuse, N. Y., has changed its name to Precision Castings Co., Inc.

A. L. Ryder, Inc., 160 E. Colorado St., Pasadena, Cal., has changed its firm name to Pioneer Motor Co.

Brown & Sharpe Mfg. Co., Providence, R. I., has removed its Philadelphia office to 1103-1105 Liberty Bldg.

Burton, Griffiths & Co., formerly at 110 W. 40th St., New York City, are now located in the Metropolitan Building.

Excelsior Needle Co., Torrington, Conn., manufacturer of Dayton swaging machines, has changed its name to Torrington Co.

A/S National Industri, Christiania, Norway, has moved its New York office, in charge of Bjarne Holm-Hansen, from 309 Broadway to 90 West St.

Wagner Electric Mfg. Co., St. Louis, Mo., has opened a sales office at 116 Auburn Ave., Atlanta, Ga., in charge of Charles M. Welch, formerly office manager of the Indianapolis branch.

Nutter & Barnes Co. has moved its plant to Greenfield, Mass., forming a part of the machinery division of the Greenfield Tap & Die Corporation. All correspondence should be addressed, Greenfield Tap & Die Corporation, Machinery Division, Greenfield, Mass.

Chicago Rawhide Mfg. Co., 1301 Elston Ave., Chicago, Ill., is just completing an addition to its plant of 30,000 square feet. The company manufactures a complete line of mechanical leather goods—rawhide pinions, gear blanks, belting, lace leather and packings.

General Electric Co.'s Atlanta repair shop is fully equipped to give its customers repair service on all classes of direct- and alternating-current apparatus. Correspondence in regard to repair work should be addressed to the engineering department, General Electric Co., Third National Bank Bldg., Atlanta, Ga.

W. B. Knight Machinery Co., St. Louis, Mo., manufacturer of the Knight milling and drilling machine, has erected a new factory at Vandeventer and Pine Sts., which it expects to occupy about December 15. The shop is a one-story brick building, 100 by 150 feet. All the machines will be electrically driven.

Alfred Herbert, Ltd., has removed its New York offices from 30 Church St. to 54 Dey St., where much larger quarters have been secured by W. J. Fuller, the manager. This move has been made necessary by the great increase in the work of this office, which made it impossible to get along in the former quarters.

Russell Motor Car Co., 93 Dewey Ave., Buffalo, N. Y., has been incorporated. The company has purchased a large factory and is now equipping it with machinery for undertaking a large contract for the United States Navy Department. Manufacturers of machine tools are requested to send copies of their catalogues to the company.

J. T. Slocomb Co., Providence, R. I., manufacturer of machinists' tools, announces that improvements in the company's building have been completed and that in the past year the floor area has been almost trebled, the new space being almost entirely equipped with new machinery. One of the departments is now running night and day with three shifts of men.

Haynes Stellite Co., Kokomo, Ind., is sending to customers an announcement of the exchange value of "Stellite" scrap. All "Stellite" scrap except that on electric welded tools is now rated at $4 a pound in exchange. For example: if ten pounds of "Stellite" scrap are sent to the company, the sender will be credited $40 on "Stellite" standard bar stock, which will be billed at the current price.

Niles-Bement-Pond Co., 111 Broadway New York City, has purchased fifty acres of land in the Kearney section of the Newark meadows. The acreage has frontages on the Lincoln Highway and the Hackensack River directly opposite the site of the United States Steel Co.'s federal shipbuilding plant. There are no immediate plans for the improvement of this property, although it is understood that in the future it will be used for an extensive manufacturing plant.

Cincinnati Lubricant Pump Co., Cincinnati, Ohio, manufacturer of the "Fulflo" pump for machine tools, is building a new factory and foundry at Blanchester, Ohio, about thirty miles from Cincinnati on the B. & O. Railroad. The company will erect a two-story brick building, 50 by 100 feet, for manufacturing purposes, and a foundry, 30 by 75 feet, which it expects to occupy about January 15. It is the intention to extend the line of lubricating pumps to include those used in airplanes and automobiles.

Bond Foundry & Machine Co., Manheim, Pa., has purchased the property, plant and good will of the Queen City Foundry Co., Toronto, Canada. The plant will be operated as the Bond Engineering Works, Ltd.; it will continue to manufacture gray iron castings for the trade, and in addition will make a line of power transmitting specialties consisting of shaft hangers, couplings, collars, etc. Additional buildings will be erected to take care of the increased business. The works will be under the management of H. M. Lee.

Seneca Falls Mfg. Co., 330 Fall St., Seneca Falls, N. Y., has been reorganized as a result of the purchase of the interests of Messrs. Davis and others. The board of directors comprises Patrick Sweeney, William H. Foxall, L. Sherman Adams and Levi S. Chapman. The officers are Marcus A. Coolidge, president; Alton F. Tupper, vice-president; and Marshall J. Root, secretary and treasurer. The general management of the business will be under the charge of Mr. Root. Additional equipment will be installed and the output will soon be doubled.

Standard Aero Corporation of New York, organized in June, 1916, has found it necessary, due to business expansion, to organize an additional company under the name of the Standard Aircraft Corporation. These two organizations, under practically the same management, will divide their activities as follows: The Standard Aero Corporation of New York will continue as an engineering and experimental organization, while the Standard Aircraft Corporation will devote itself to the manufacturing of airplanes, with plants at Plainfield and Elizabeth, N. J. Both corporations have their offices at Elizabeth, N. J.

Betts Machine Co., Wilmington, Del., has sold its real estate, buildings and equipment to E. I. du Pont de Nemours & Co., Wilmington, Del., who also took over the accounts receivable and assumed all outstanding obligations, and will complete all unfilled orders on the books of the company at the time the sale was made. The du Pont Co. will also use the plant for the construction of machine tools required in their various machine shops. The Betts Machine Co., now of Philadelphia, Pa., has retained the patents, patterns, drawings, jigs, fixtures, etc., and has negotiations under way for a continuation of the manufacture of its line of machine tools. M. A. Sherritt is now president and C. H. Stoer is secretary and treasurer of the Betts Machine Co.